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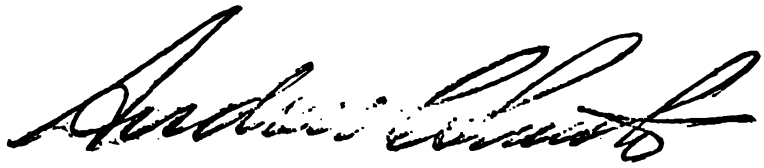

LIPPINCOTT'S NEW MEDICAL SERIES

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THE

PRINCIPLES AND PRACTICE

OF

SURGERY

DESIGNED FOR STUDENTS AND PRACTITIONERS

BY

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PREFACE.

THE object of this volume is to present the subject of general surgery in the way best adapted for the uses of the general practitioner and student. For this reason, consideration of the several branches of special surgery, such as ophthalmology, otology, etc., has been omitted. The large clinical experience of the author and his many years of teaching work have convinced him that there is much need for such a book. At a time when the various special subjects in medical science require individual text-books to expound their first principles, it is clearly impracticable to attempt anything like a proper presentation of them within the limits of a volume devoted to general surgery. In every instance the effort has been to present the subject matter from the most practical point of view. Condensation has been used as much as is consistent with clearness and a fair exposition of the subjects by giving special attention to practical points and avoiding long theoretical discussions.

In addition to the many illustrations made especially for this volume, the author desires to acknowledge his indebtedness for some of the cuts to the International Clinics, Agnew's Surgery, and the works of Wharton and Curtis, and White and Martin.

Grateful acknowledgment is made to Surgeon-General Walter Wyman for numerous favors and opportunities afforded in the preparation of this work; also for valuable aid to Doctors White, Austin, Geddings, Rosenau, Parker, and Anderson, of the Public Health and Marine Hospital Service.

My thanks are due to several of the students of the Georgetown University and the interns of the Georgetown University and Emergency Hospitals for case histories, photographs, and pathological specimens, to Dr. Gramm for photomicrographs, and to the editor and publishers for their aid, encouragement, and unfailing courtesy.

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THE PRINCIPLES

AND

PRACTICE OF SURGERY.

SECTION I.—GENERAL SURGERY.

CHAPTER I.

INFLAMMATION.

INFLAMMATION is the sum of the phenomena which take place in the tissues as the result of injury (Councilman). It is always reparative and regenerative, and when it is attended with destructive action it is for the purpose of getting rid of something hurtful in order that repair may take place. The necessity for repair may be the result of mechanical injury, as that produced by the surgeon's knife, or of the more destructive processes which follow the invasion of the tissues by pathogenic organisms.

Histology.

This may be studied under: 1. Changes in the blood-vessels and circulation. 2. Changes in the tissues surrounding the blood-vessels.

1. CHANGES IN THE BLOOD-VESSELS AND CIRCULATION.

These include: (*a*) Dilatation of the small arteries, veins, and, lastly, capillaries, preceded by momentary contraction. (*b*) Acceleration of the blood-current; soon followed by (*c*) Slowing of the blood-current, beginning in the veins (hyperæmia). (*d*) The leucocytes cling to the vessel wall and lag behind the blood-current. There is a considerable increase in the number of these cells and also frequently of the third corpuscle, or blood-plaque, while certain organs, as the spleen and lymphatic glands, may become enlarged. (*e*) Oscil-

lation, then stasis, followed by thrombosis when the walls of the capillaries die. (*f*) Escape of corpuscles and fluid from the vessels. This begins with slowing of the blood stream, when the white blood-cells are seen to lag behind the current and to accumulate on the interior of the walls of the veins, also, but to a less extent, in the walls of the capillaries. In a short time some of the leucocytes sink into the vessel wall and pass, by their amœboid properties, through to the other side (diapedesis). If the inflammation be intense, red corpuscles also escape into the surrounding tissues. The fluid from the blood likewise escapes, and as the lymphatics become unable to take it off it accumulates in the connective tissue and may finally reach the surface with a number of small round cells and red blood-corpuscles, where with the fibrin it forms a coagulum or false membrane. The cells probably escape from the blood-vessels through the stomata in the cement substance which unites the endothelial cells of the capillaries.

ORIGIN OF THE NEW CELLS.—(*a*) Cohnheim taught that the cells come from the blood and are emigrated white cells. (*b*) Virchow believed that they were the result of proliferation of the connective-tissue cells. (*c*) Stricker taught that they came from both sources. The fact seems to be that in severe injuries the leucocytes tend to predominate, while in slight injuries the proliferation of fixed tissue cells predominates. It is by multiplication of the fixed tissue cells that regeneration and repair take place, the polynuclear cells probably furnishing the pabulum.

EXUDATION OF FLUID.—Some fluid exudes normally, also a few leucocytes. The composition of inflammatory effusion is not constant. It differs from liquor sanguinis in containing less albumin and having a slighter tendency to coagulate. In the more severe inflammations it contains red blood-cells and resembles plasma, while in the less severe it is like the fluid of mechanical hyperæmia.

2. CHANGES IN THE INFLAMED TISSUES.

The tissues outside of the blood-vessels become distended with the fluid and cells which have escaped. The tissue-fibres are swollen, indistinct, and softer than usual. In addition to the leucocytes the cells in the tissues are increased by proliferation of the fixed tissue cells as a result either of the original injury or of the stimulation due to the invasion by the fluid and leucocytes. The greater the injury the more marked will be the degenerative changes and the leucocytes will exist in large numbers, while in less marked injuries the regenerative process is evident sooner and there is a greater proliferation of fixed tissue cells; this proliferation takes place by karyokinesis, the

simple or indirect method of cell-multiplication. The cells in the tissues produced by the accumulation of leucocytes and the proliferation of the various fixed tissue cells as connective tissue, bone, muscle, nerve, etc., form a mass of small round or oval cells, called *embryonic, juvenile*, or *indifferent* tissue.

Functions of the Leucocytes and of the Fixed Tissue Cells.—The mixture of leucocytes and fixed tissue cells may be absorbed or converted into embryonal cells, which in turn may become pus-cells through the action of pus-germs, should the tissues become infected, but proliferation continues, and unless the tissues are too severely injured to rally, from the embryonic tissue develop fibroblasts, osteoblasts, myoblasts, etc., which produce the tissues to replace those that have been injured. The leucocytes have been regarded as scavengers which consume the broken-down materials which result from inflammation,—fragments of blood-clots or carmine granules, when used experimentally, having been found in these cells. Sternberg and Metschnikoff developed the theory and established the fact of *phagocytosis*. This means that in certain cases the leucocytes meet the invading bacteria and by means of their amœboid properties take them into their own tissue and destroy them. Leucocytes are called *microphagocytes*, and the larger cells developed from the fixed connective-tissue cells, *macrophagocytes*. The latter are thought to consume the smaller cells after their struggle with the bacteria, and thus promote absorption. One theory of the immunity which animals have against certain diseases is based on the ability possessed by the phagocytes to destroy the invading bacteria—non-immunity meaning that the invading bacteria overcome the phagocytes and thus gain admission to the system. Others believe that the leucocytes may be deleterious by acting as vehicles for conveying the bacteria to distant parts of the body and thus spread infection.

The fixed tissue cells may die from the effects of bacteria or their ptomaines and become pus-cells, but it is from these fixed tissue cells that the permanent tissues are repaired, the leucocytes probably nourishing them during the process (Klebs). According to Senn, each tissue is repaired under favorable circumstances by proliferation of its own cells; thus, connective tissue by fibroblasts, bone by osteoblasts, muscle by sarcoblasts, nerves by neuroblasts, etc. Fibroblasts seem hardier, more numerous, or more prolific than the other cells, so that, when repair fails to take place by the development of the proper tissue cell, connective tissue takes its place. For example, a defect in a muscle too great for repair by the development of the sarcoblasts into muscular fibres is made good by the development of

fibroblasts into connective tissue. Observations and experiments on man and the lower animals have proved the possibility of the reproduction not only of the simpler tissue but also of parts at least of complex organs, as the liver, spleen, kidney, testis, and brain.

The third corpuscle in the blood is about twenty times more numerous than the red blood-corpuscles. Its function seems to be to aid in the production of fibrin outside of the vessels or within, where it forms white mural thrombi, coating over and making smooth any injury of the intima.

INFLAMMATION IN NON-VASCULAR STRUCTURES.—In the cornea and in cartilage, where blood-vessels normally do not enter, the nearest blood-vessels dilate; there are an exudation of serum and a wandering of leucocytes into the corneal spaces, followed by proliferation of the corneal cells. If the injury is severe new blood-vessels are formed and extend into the non-vascular tissue. There is apt to be opacity of the cornea, because the repair is made by connective tissue. In slight injuries no opacity follows, as repair takes place by means of the corneal cells. The process of inflammation and repair is similar but slower in cartilage, the blood supply coming from the bone or synovial membrane.

THE ESSENTIAL LESION OF INFLAMMATION.—By exclusion of the blood, tissue elements, and nerves, by the fact that the earliest phenomena of inflammation are vascular, that injury of vessels causes these phenomena, that stasis can be produced in vessels in which milk or defibrinated blood is circulating and cannot be produced in vessels whose vitality has been destroyed by injection or metallic poisons, we are forced to conclude that the essential lesion is produced on the *vessel wall;* this change, according to Cohnheim, being of a *molecular* or *chemical* character, increasing the friction between the blood and vessel wall and rendering the latter more permeable.

Varieties or Degrees of Inflammation.

The *varieties* or *degrees* of inflammation depend on (1) the resisting power of the tissues, (2) the intensity of the cause, and (3) the duration of its action (Green). They are:

1. SIMPLE OR SEROUS inflammation results from slight injuries, traumatic, thermal, or chemical, and not from infection with bacteria unless in very small numbers. There is a serous exudate from the vessels, containing excess of albumin but very few leucocytes and slight tendency to coagulate. Examples: blisters; chronic effusions into the pleural cavity, tunica vaginalis testis, or joints; effusions into the substance of a part, constituting œdema; and catarrh of mucous surfaces.

2. FIBRINOUS inflammation is the result of more intense injury or infection. The exudate contains more albumin and leucocytes, and has a greater tendency to coagulate and form "lymph" on the surface or in the tissues. "Fibrin containing leucocytes constitutes inflammatory lymph" (Green). Example: "lymph," which forms on serous surfaces, as the pleuræ, and which forms the temporary medium for bringing the edges of a wound in union by the first intention. Lymph also glazes the surface of an open wound, and when it occurs in a mucous membrane as well as on its surface, it is called "croupous" or "membranous."

3. PRODUCTIVE INFLAMMATION.—The ultimate object of all inflammations is repair and production of new tissue when needed to make losses good, but this tendency is more marked where the injury is slight and long continued. *Granulation tissue* forms. This consists of numerous capillary loops covered with round cells with one or more nuclei. These are succeeded or displaced by cells twice the size of leucocytes, containing a large vesicular nucleus,—*fibroblasts*, which branch, the processes interlacing and forming bundles of fibres, and so become fibrous, connective, or scar tissue. The fibroblasts probably feed on the degenerating leucocytes. Scar tissue is at first quite vascular, the scar being redder than the surrounding parts, but the tendency to contract, so characteristic of this tissue, continues, the vessels disappear, and in the course of a few weeks or months the scar becomes white.

4. INTERSTITIAL inflammation is the term applied to the process when it is primarily limited to the connective tissue between the essential elements of an organ. It seldom leads to suppuration or exudation, but there is considerable cell multiplication and increase in the connective tissue, leading to secondary changes in the essential cells of the organ due to interference with their nutrition. In *parenchymatous* inflammation the essential cells of the organ seem to be primarily affected.

5. SUPPURATIVE or PURULENT inflammation is nearly always the result of *bacterial infection*, a more intense and prolonged irritant than that which causes the serous or fibrinous inflammation, though it often follows these. There is little or no formation of lymph or of new vessels, and what lymph may have been formed is destroyed when suppuration sets in.

6. HEMORRHAGIC inflammation is characterized by the exudation of red corpuscles in excess. It indicates a high grade of inflammation and serious interference with the circulation, threatening thrombosis or gangrene.

Etiology of Inflammation.

The *causes* of inflammation are *predisposing* and *exciting*.

PREDISPOSING CAUSES are those which lower the vital functions, or produce a *locus minoris resistentiæ*, as shock, hemorrhage, gout, rheumatism, diabetes, nephritis.

EXCITING CAUSES—simple and infective:

Simple	1. *Traumatic*, including any injury from violence. 2. *Chemical*, as fly-blister, snake-bites, stings of insects, vegetable irritants, as poison-oak, croton oil, and turpentine. 3. *Thermal*, excessive heat or cold.
Infective	4. Bacteria and protozoa.

Symptoms of Inflammation.

These are *redness*, *heat*, *swelling*, *pain*, and *impaired function*.

Redness is due to the increased flow of blood to the part. During the active stage the color is scarlet, but as stagnation comes on the color deepens to a dusky or purple hue. Pressure causes the redness to disappear, but it returns as soon as the pressure is removed. The color of an inflamed mucous membrane is brighter than that of the skin, the blood-vessels being nearer the surface. In non-vascular structures the color is absent, but it is marked in the adjoining vascular parts. Lividity of a part may mean impending sloughing, intense venous congestion, or failure of the heart and lungs. If the last, the color returns slowly after pressure.

Heat is due to the increased quantity of blood flowing through the part in a given time, and can never be greater than the blood temperature or the temperature of the internal organs.

Swelling is due in a slight degree to dilated blood-vessels, but chiefly to the exudation of fluid and corpuscles from the blood and proliferation of the tissue cells. It may be caused entirely by fluid, as in "œdema," in which the parts "pit" on pressure; or by cells, as in orchitis and in "solid œdema," where the parts do not "pit" on pressure. Swelling is most marked where the cellular tissue is loose and abundant, as in the scrotum and eyelids; least so in firm, compact tissues, as periosteum and bone.

Pain is due to pressure of the exudation on the nerve-endings, to inflammation of the nerves themselves, and perhaps to chemical irritation. It varies with the tension and sensitiveness of a part as well

as with the rapidity of effusion, being severe in acute inflammation of bone, periosteum, or testis. It is usually associated with tenderness. On the surfaces it is burning and smarting in character; in dense structures it is gnawing, boring, or throbbing. Throbbing is often an evidence of suppuration. Pain is not always felt at the point of inflammation. In hip disease pain is often felt in the knee; when the main trunk of a nerve is irritated, the pain is felt in the area of its distribution, and pain in one branch of a nerve may be referred to the area of distribution of some other and distant branch.

Impaired function may be manifested by increased irritability, as in colitis, cystitis, conjunctivitis; or diminished activity, as in myositis and arthritis, or in derangement of the special senses. Constitutional symptoms may be present, especially in the infective forms, as chill, fever, accelerated pulse, headache, nausea, leucocytosis, or a typhoid state with delirium, diarrhœa, and great prostration.

SPREAD OF INFLAMMATION takes place by means of the active agents of the process, or by their products being carried or finding their way through the blood-vessels and lymphatics, as abscess of the liver following amœbic dysentery, or buboes following ulcers of the genital organs.

Terminations of Inflammation.

1. *Resolution* is the most frequent termination of inflammation, but cannot occur if suppuration or necrosis have taken place. In resolution the different stages of inflammation are passed through without destruction of tissue, and there is a gradual return to the normal condition. The walls of the affected vessels regain their tone, contract, and quicken the blood-current, which has been in stasis, while the escape of fluid and corpuscles from the blood-vessels ceases. The inflammatory exudate is absorbed by the veins and lymphatics, parts of it first undergoing fatty degeneration. Delitescence means the abrupt termination of inflammation in an early stage.

2. Inflammation terminating in *new growth*, or productive inflammation, is the form in which repair is best observed. This requires a plentiful blood-supply and the injury must not be too severe or the irritation too long kept up.

3. *Necrosis* occurs as a result of interference with the circulation, or of the intense action of the poison or ptomaine on the tissue cells. *Coagulation necrosis*, in which the cells undergo coagulation followed by fatty degeneration, may occur, or the destruction of tissue may be still greater so that ulceration or gangrene results.

Treatment.

The treatment is local and constitutional.

LOCAL TREATMENT.—First, remove the cause of the inflammation, if possible, such as a foreign body in the tissues, or a local infection of any kind. Place the part in the best position, usually elevated, to prevent congestion, and secure absolute rest by splints if necessary. In *acute* inflammation with swelling, tense and brawny skin, incisions may prevent suppuration or gangrene. In milder cases the use of hot or cold applications or leeches may be tried. Do not use solutions of carbolic acid too strong or too long, for fear of producing local gangrene of the skin. In chronic cases the use of counterirritants by means of blisters, friction, and massage is to be recommended. Compression by means of an elastic bandage is good treatment in chronic effusions in joints.

CONSTITUTIONAL TREATMENT.—In *asthenic* or *typhoid* conditions alcoholic stimulants, strychnine, etc., are indicated. For severe pain and in order to produce sleep, anodynes and hypnotics, as morphine, may be necessary. Purgatives are of the greatest importance, especially in inflammation involving the peritoneum, when sulphate of magnesium should be used in drachm doses every hour till free purging is produced. Venesection is sometimes valuable in the first stages of inflammation of the brain or lungs. Suitable diet should be prescribed,—light, nutritious, but not stimulating. Milk suits many cases, but it sometimes ferments and causes gaseous distention. Meat soups and broths, eggs, entire or simply the whites, rice, and arrow-root may be given. In chronic cases and during convalescence tonics, as iron, quinine, strychnine, mercury, or arsenic, may be given with advantage.

CHAPTER II.

WOUNDS.

A WOUND may be defined as "a solution of the continuity of any tissue, produced directly or indirectly, by sudden mechanical force." The word is from the Anglo-Saxon *wund*, probably from *wenden*, to strive. As ordinarily used, a wound means an open injury to the soft tissues; but broadly speaking, it includes contusions, sprains, and fractures, whether open or subcutaneous. They may be classified as *closed* or *subcutaneous* wounds and *open wounds*. According to the presence or absence of infection, they are called *septic* and *aseptic* wounds.

CONTUSIONS.

A contusion is a subcutaneous wound produced by a blunt body which fails to break the skin. It varies in severity from the slight injury which may be caused by a blow from the hand to that in which the tissues, except the skin, are extensively destroyed, as by the passage of a heavy wagon over a limb.

Pathology.—The amount of damage done beneath the skin depends on the severity of the violence and the nature of the tissues injured; for example, a blow on a part in which the bone is near the surface will produce more contusion than the same force exerted on soft, yielding tissues. The soft tissues are apt to suffer most, muscles, blood-vessels, and nerves being bruised or divided, resulting in hemorrhage, neuritis, paralysis of the nerve-fibres, pain, swelling, and impaired or lost function. If a number of small blood-vessels are broken, especially the blood-vessels in the skin or just beneath it, blood is effused among the tissues, giving rise to a dark-blue or black discoloration called *ecchymosis*. If a large vessel is wounded so that blood escapes in sufficient quantity to make a cavity for itself in the tissues, it is called a *hæmatoma*. If a nerve is not severed it may be bruised and its *vasa nervorum* ruptured, with extravasation of blood into the neurilemma, which may result in neuritis. The sheath of a muscle or the muscle-fibres may be ruptured. The periosteum may be involved in a contusion and a hæmatoma may form beneath it.

Symptoms.—The first symptoms are usually pain, swelling, tenderness to pressure, and ecchymosis, if the wound be superficial. Where

deeper structures are involved, as in the thigh, the ecchymosis may not appear for several days. The swelling is due to the effusion of blood and to the increased amount of serum and cell proliferation. Pain is caused by pressure of the exudate on the nerve-fibres, or numbness may result from the same cause or from destruction of these fibres, in which case there would also be paralysis. Shock occurs in some cases, especially in contusions of the head or the abdomen.

Treatment.—The first indication is to secure rest of the parts in the most comfortable position. Pain may be relieved by the application of gauze wrung out of hot water, or, if more agreeable, cold applications may be used. As evaporating lotions, use alcohol and water, spirits of camphor, tincture of arnica, witchhazel, or a solution of chloride of ammonium. No other treatment is needed for the extravasation. A hæmatoma may be left for absorption, but if large and there is no tendency to absorption at the end of three or four weeks, it may be aspirated or incised. A hæmatoma from a large artery, or a *traumatic aneurism* enlarging rapidly, requires immediate ligation of the wounded artery. Great swelling of the tissues from effusion or inflammation, threatening the vitality of the part, calls for free incisions. Massage may be used in the later stages of the contusion to aid in restoring the tissues to their normal function.

OPEN WOUNDS.

Open wounds are divided into eight classes,—namely, *contused*, in which the wound is inflicted by a blunt body which bruises the tissues as it severs them; *incised*, when inflicted by a body with a sharp edge; *lacerated*, when the tissues are irregularly torn; *punctured*, when inflicted by pointed instruments; *penetrating*, when the wound enters a cavity; *perforating*, when it passes through a cavity; *poisoned*, when some infectious material is carried in; and *gunshot*, when the wound is the result of some missile impelled by the explosive force used in firearms.

Wounds often partake of the nature of several of the varieties given; as, an injury from a gunshot may be a contused, lacerated, perforating, poisoned wound. Lacerated wounds are more or less contused. Any of them may be poisoned. Open wounds are more apt to be septic than closed ones.

Contused and Lacerated Wounds.—A blow on the head with a club, laying open the scalp, would produce a contused wound, while a wound inflicted by the horn of a bull would be an example of a lacerated one. Accidents from machinery, as the crushing of limbs by the passage of heavy wheels or their avulsion from the body, are

examples in which the wounds are both contused and lacerated. Such injuries have a characteristic *appearance*, the surface being ragged, possibly with strips of tendon, muscle, or fibrous tissue hanging from the wound, which is likely to be soiled with foreign matter—as sand, coal dust, and machine oil. The *pain* is of a dull aching character, but is sometimes completely absent, from the effects of shock, which is often a marked symptom in severe injuries of this nature. The hemorrhage is usually slight, owing to the twisting and bruising of the vessels which have been severed. Often a femoral or brachial artery is found severed after railway accidents, with the ends closed so firmly as to prevent the escape of a drop of blood. There is great danger, however, of intermediate or secondary hemorrhage from detachment of clots, or sloughing of the injured coats of the vessels. Sloughing and gangrene are by no means uncommon on account of the severe injury to the tissues, the full severity of which may not be apparent at the first examination. Septic infection is liable to take place, on account of the difficulty of disinfection and the impaired vitality of the parts.

Treatment.—Shock or *hemorrhage* may require the surgeon's attention. If much hemorrhage is going on, arrest it at once by compresses or ligation of the bleeding vessels. Treat shock by giving aromatic spirits of ammonia, strychnine, or digitalis; or, if the result of hemorrhage, by intravenous infusion of physiological salt solution. One of the most important indications in the treatment of such cases is the thorough cleansing and disinfection of the wound. If soiled with soot and grease, give an anæsthetic and apply turpentine, then soap and water with a scrubbing brush, enlarging the wound if necessary in order to enter all the recesses, then flush out with bichloride solution, 1 to 1000. Cut away ragged and semi-detached portions of tissue. Severed arteries must be tied, even though not bleeding, as reaction might be followed by hemorrhage. Divided tendons, nerves, and muscles must be sutured together with catgut or fine silk. If there has been much crushing, provide drainage by the use of rubber or glass tubes or gauze, making counter-openings if necessary. Such wounds heal by the second or third intention; that is, by granulation and the union of granulating surfaces, although some parts of the wound may heal by primary union. Apply a dressing of iodoformized gauze next to the wound, cover it with sterilized gauze and absorbent cotton, apply a bandage around the whole to keep it on, and place the wounded part in the position which will give most comfort to the patient and at the same time prevent undue tension on divided structures which may have been united.

BRUSH-BURN.—This is a form of contused wound produced by friction of the surface of the body, as by sliding down a steep incline, or by slipping rapidly down a rope held in the hands, or by contact with a rapidly revolving belt or machinery. The epidermis only may be injured, or the entire thickness of the skin may be involved.

Treatment.—The wound should be disinfected and dressed aseptically. Superficial sloughs are likely to follow such injuries.

INCISED WOUNDS.—Incised wounds, being produced by sharp cutting edges without impairment of the tissues by contusion or crushing, present the most favorable conditions for primary union and quick recovery. Such wounds are inflicted by the surgeon. There is more or less gaping of the wound, the pain is of a sharp burning character, and hemorrhage is free, as the blood-vessels are severed in the manner least likely to obstruct them and prevent bleeding.

Treatment.—The greatest danger of incised wounds is immediate hemorrhage, and this must be arrested at once by ligation of the bleeding vessels, or, if moderate, simply by suturing the edges of the wound together after disinfection. Drainage is unnecessary, unless hæmostasis or disinfection has been imperfect. The stitches should be removed at the first or second dressing, some time between the seventh and tenth days. Adhesive plaster, not being sterile, should not come in contact with the wound, but may be applied outside of the dressings.

PUNCTURED WOUNDS are inflicted by pointed instruments, as swords, bayonets, trocars, daggers, canes, or umbrellas, and may partake of the nature of either *incised* or *contused* wounds. Their depth is greater than their cross-section.

PENETRATING WOUNDS, in which the weapon enters a cavity without emerging, and PERFORATING WOUNDS, in which the weapon passes through a cavity, are frequently seen in connection with punctured wounds. Such wounds, if free from infection, contusion, and severe hemorrhage, heal without difficulty. On account of their depth and the narrow track leading to the bottom, infection is likely to prove serious, and if suppuration occurs pus may be confined and give rise to grave symptoms. Important vessels may be wounded and give rise to hemorrhage, which may occur in a cavity which has been penetrated, as in stab wounds of the chest; or the weapon may pass between a vein and an artery, injuring one or both, and be followed by aneurismal varix, varicose aneurism, or traumatic aneurism.

Treatment.—The greatest dangers from punctured wounds are *hemorrhage* and *infection*. Hemorrhage may be arrested by packing, but, if necessary, the wound must be enlarged and the bleeding

vessel secured. If the pericardium, the lung, or a mesenteric vessel be the source of hemorrhage, it may be necessary to open the chest or the abdomen in order to arrest the bleeding. Infection may be carried in by the instrument inflicting the wound, or it may result from the escape of the contents of wounded viscera, as in punctured wounds of the stomach or intestines. If there is reason to suspect infection, and especially in wounds caused by nails or the teeth of dogs or reptiles, open the wound freely, disinfect it thoroughly, and provide drainage. Foreign bodies broken off or left in the tissues should be extracted immediately, if possible. To find small bodies, as fragments of needles, secure a bloodless field by Esmarch's bandage, raise an oval flap of skin and fascia with the wound of entrance in the centre, and the body is usually exposed. To remove a fish-hook buried in the tissues, cut off the end to which the line is attached and force the point of the hook on through the tissues. If this be impossible, cut it out.

Poisoned Wounds. — A poisoned wound is one into which noxious substances, either of a chemical or microbic nature, have been conveyed. Keen and White divide poisoned wounds into three classes: First, the *mixed* or *biochemical*, in which, in addition to the action of the bacteria on the living tissues, the toxins produced by them play an important part; second, *chemical*, in which some chemical product, animal or vegetable, is the poisonous agent; and, third, the *microbic*, in which certain specific diseases, as anthrax, tetanus, actinomycosis, etc., are produced. No sharp line of division can be drawn between the *mixed* and the *microbic* infections, as in both ptomaines and toxins are present. *Mixed* or *biochemical* wounds include dissecting wounds and those received by butchers, fish-dealers, oystermen, and others who handle animal products.

Pathology.—The special organism producing the infection is not known, but there are probably several. The organism gains entrance by a slight wound or abrasion, rarely through the unbroken skin. Here it produces its ptomaines or toxins, which, acting on the tissues, prepare them for further invasion by the bacteria, or, circulating in the blood, produce toxæmia or septic intoxication. Dissecting wounds may be taken as the type of this class, which includes, besides those mentioned, wounds received at necropsies or in surgical operations on cases of septic peritonitis, erysipelas, or septicæmia. The infection is more likely to be received from bodies recently dead than from those in an advanced stage of decomposition.

Symptoms.—If a large amount of toxins enter into the circulation, *acute toxæmia* or *septic intoxication* results, with great prostration, rapid, feeble pulse, delirium, and usually death in a few days. In

other cases a *lymphangeitis* occurs. The wound may be painful, red, and swollen, with red lines along the surface of the skin, extending up the arm to the axilla, the glands of which become swollen and may suppurate; or cellulitis may develop and extend rapidly, with symptoms of pyæmia, rigors, profuse sweats, rapid pulse, and elevated temperature. Sometimes the inflammation is limited to the hand, and gangrene of the finger or palmar abscess, or both, may result.

Treatment.—Prophylactic treatment is the adoption of methods which will prevent infection, the use of rubber gloves or other protection to the hand in making necropsies; if a wound is received, it should be immediately disinfected, and, if punctured, enlarged and sucked, then cauterized and dressed antiseptically.

Curative Treatment.—If the first symptoms appear as a *lymphangeitis*, with enlargement of the axillary glands, remove the latter in order to prevent a general infection. If *cellulitis* occur, make early and free incisions to prevent gangrene and sloughing, irrigate, and dress antiseptically. As constitutional treatment, give stimulants, tonics, and proper food. Local treatment is of little use in cases which exhibit early symptoms of acute toxæmia. When the inflammatory process affects the palm of the hand, make deep incisions through the palmar fascia.

Chemical Wounds.—The chemical class of poisoned wounds includes the bites and stings of insects and bites of reptiles. The poison is of a chemical nature, in some cases containing formic acid.

Symptoms.—Beyond a certain amount of pain and swelling no inconvenience is felt in the majority of wounds made by insects. In old persons or the very young, or in those debilitated by illness, the symptoms may be severe. The location of the injury is important, as the sting of a bee or wasp on the nose or tongue may be followed by great shock or œdema of the glottis. The number of such wounds inflicted is also important; a swarm of bees or hornets may produce death by toxæmia or shock.

The *treatment* for bee-stings or insect-bites is the application of an alkali to neutralize the acid poison. A solution of carbonate of sodium, dilute aqua ammoniæ, carbolic acid and camphor, a mud poultice, or a wet quid of tobacco, have all been used as local applications.

Snake-Bites.—The venomous snakes of the United States are the rattlesnake, moccasin, and copperhead. It is said that the Gila monster is also poisonous. In serpents the poison is secreted by a gland which lies against the side of the skull below and behind the eye on each side. From the poison-sac a duct leads to the base of the fang.

which may be hollow or contain a groove on the surface along which the poison flows when the animal bites.

Pathology.—In appearance serpent-venom is a pale-amber or deep-yellow, viscid fluid, containing albuminoid elements which are not well understood. Its action on the living tissues is the production of rapid necrosis and disintegration of the red blood-corpuscles; the blood is rendered incoagulable and the walls of the capillaries incapable of resisting the normal blood-pressure; hence the rapid extravasation which takes place. Congestion of the brain and spinal cord are found and sometimes slight hemorrhages. Death results from cardiac or respiratory paralysis, probably due to hemorrhage in the medulla.

Symptoms.—When the poison enters a vein the symptoms come on rapidly with pain and swelling, and the tissues become discolored from the extensive extravasation of blood. The pulse is rapid and weak, the respiration depressed and perhaps labored; there are cold perspiration, faintness, nausea, and vomiting, which may end in coma and death within from two to twenty-four hours from paralysis of the cardiac and respiratory centres. If the patient survive longer than forty-eight hours, he may yet die as a result of gangrene and sapræmia.

Treatment.—The first object is to prevent or limit the entrance of the poison into the general circulation. If the bite is on an extremity, a series of ligatures, say three, one above the other, should be tied around the limb tight enough to prevent venous circulation. These may later be gradually relaxed and removed, one at a time, beginning with the one nearest the body. The wound should be sucked, if there are no abrasions in the mouth; or it may be excised, or enlarged and cauterized with nitric acid or the actual cautery; or, if on a finger, it may be amputated, provided this is done within a few seconds after the bite. No certain antidote is known, but permanganate of potassium in one per cent. solution injected freely into the tissues around the wound seems to act well. The most common remedy is alcohol in large doses. This probably acts not as an antidote but simply as a stimulant to sustain the vital force until the effects of the poison pass away. Do not give too much alcohol, as the effects might be as disastrous as those caused by the snake-venom. Antivenene serum in twenty cubic centimetre doses, hypodermatically, every three or four hours, has been used (Calmette). Also, intravenous injection of aqua ammoniæ. Good results are reported from the use of large doses of strychnine nitrate.

Gunshot Wounds.—A gunshot wound is a lesion produced by a missile projected from a firearm. In civil life such wounds are

produced by shot used in fowling-pieces or pistol or rifle bullets from 22 to 48 calibre; that is, .22 to .48 of an inch in diameter. In military service the wound may be inflicted by rifle or pistol balls, grape-shot, cannon-balls, or fragments of shells or their contents. The modern rifle used by the United States army, called the Krag-Jörgensen, carries a bullet 30.63 millimetres long and 7.62 millimetres calibre, made of lead, cupro-nickel, and steel. The penetrating power of such a ball is five or six times that of the old-fashioned .45 lead ball. This ball is called humane because it penetrates the tissues of the human body with the smallest amount of injury, except at close range, less than five hundred metres, when a bone may be shattered, surrounding tissues extensively lacerated, the brain, liver, and other organs completely disorganized; the apparently explosive action being due, according to Stevenson, to "the high velocity of the bullet, which is transmitted as energy to the soft tissues, causing them to move outward in lines from the axis of the bullet's track with such a degree of force that they act as secondary missiles on the neighboring tissues, and cause a still further smashing and pulping of the tissues. Even the frayed particles participate in this secondary action, but it is all the more marked when fragments of bone are driven apart in this manner." Experience in recent wars shows that the ratio of killed to wounded is much less since the adoption of the modern bullet than it was in former wars. Thus, during the civil war one man was killed for every 4.56 wounded, while in the Spanish and Philippine wars one man was killed to every 7.4 wounded. The wad or the powder from a gun fired at close range may produce serious or fatal injuries. Bits of cloth, gun-wadding, or splinters of wood are sometimes carried into the tissues by the bullet, and may be the cause of infection. Gunshot wounds, as a rule, have two openings, that of entrance and that of exit. When there is only one opening, it may be assumed that the ball remains in the tissues. The wound of exit may not be opposite that of entrance, as the course of the ball may be diverted by striking a bone or tendon. Sometimes three openings are seen, one of entrance and two of exit, caused by the ball striking a sharp bony edge and splitting into two fragments, each of which escapes by a separate opening. In the same way, where only two openings exist the inference is that the ball passed through, but if it has split in the manner described a portion of it may remain in the tissues.

Infection.—This may be produced by micro-organisms on the missile itself, or by those attached to particles of clothing, dirt, or other foreign matter carried in. The modern bullet is less likely than the old to carry infection, on account of its hard, smooth surface. In-

fection is a serious complication, as pus may burrow in the tissues and produce extensive destruction, while if no infection has taken place the wound may be treated as a subcutaneous injury and usually heals without trouble.

Effects on the Skin.—The wound in the skin is generally smaller than that produced in the tissues beneath. The aperture of entrance may show signs of powder-burn if the wound has been inflicted at short range. That of exit is larger, with a more ragged appearance. With the modern bullet the wound of entrance in the skin often appears like a small slit, which might easily escape notice.

Blood-Vessels.—Veins or arteries may be perforated, with hemorrhage at the time, or contused, giving rise to subsequent hemorrhage from necrosis of the vessel walls and the formation of arteriovenous or traumatic aneurism.

Bones.—The bone is often extensively comminuted, with fissures running into the adjacent joints, especially if struck by the old-fashioned ball or by a modern ball at close range. Beyond six hundred yards clean perforations without splintering are made, especially when the spongy bones are struck (Forwood).

Great Cavities of the Body.—A large majority of wounds of the cranial cavity are fatal. With the modern bullet wounds of the cranial cavity at short range produce extensive laceration of the brain, accompanied by comminution and fissures in the bone. According to Forwood, after sixteen hundred metres clean perforations may occur. Cases have been reported in which the bullet lodged in the brain and the patient recovered, apparently without any serious result. In other cases recovery has followed complete perforation of the brain. The greatest danger in *wounds of the chest* is *hemorrhage*, when the heart or the large blood-vessels in the root of the lung are injured. Little or no explosive effect is seen here, the perforations being small and clean with little laceration, and recovery often follows without complication. *Wounds of the abdominal cavity* rank in mortality next to those of the *cranium*, the danger being from hemorrhage, shock, and infection, but even here the prospect of recovery in a perforating wound is much greater if inflicted with the new bullet. Cases have been reported in which the new bullet has passed entirely through the abdominal cavity, apparently without injury to any important organ. The effects on the solid viscera, as the liver, spleen, and kidneys, are often explosive in character, and the laceration is enormous, even up to one thousand metres, and, in fact, considerable laceration takes place at the greatest range (Forwood). In a gunshot wound of the abdomen, according to the experiments of Von Coler and Schjerning, the liability of the viscera to injury is in

the following order: The intestines, liver, stomach, spleen, kidneys, and bladder.

Symptoms and Diagnosis.—The wound of entrance is easily seen and careful search should be made for an aperture of exit. In exceptional cases the bullet is said to have passed around the neck, emerging by the same opening through which it entered (Ashhurst). *Shock* is a common symptom in gunshot wounds. It is apt to occur when the abdominal or cranial cavities are involved, but is sometimes severe from apparently trivial wounds. *Pain* varies according to the part injured and the circumstances under which the wound is received. Under conditions of great excitement there may be no pain and the person may be unconscious of having received a wound. In other cases there is a sharp stinging, or dull, numb sensation. *Hemorrhage*, primary or secondary, is common and is the most frequent cause of death. The modern bullet is more likely to injure a blood-vessel than the old, as the vessels are not so apt to be pushed aside.

Treatment.—*Shock* or *hemorrhage* is the first symptom demanding attention and the two often coexist. *Shock* must be treated by stimulants—alcohol, strychnine, or spirits of ammonia, while the patient is soothed, reassured, and kept quiet. Put the patient to bed and if necessary apply heat to the surface. *Hemorrhage* should be treated according to general principles. Apply a compress and tight bandage over the wound or a tourniquet until the case can be dressed. If a large vessel is bleeding, ligate it in the wound. If partially severed, complete the division and tie each end of the vessel. Internal hemorrhage may require opening the abdomen, chest, or cranium. Salt solution by intravenous injection or hypodermoclysis may be necessary. There is danger of secondary hemorrhage, especially if the track of the ball lies near important vessels, until from four to six weeks have passed.

Probing.—Never probe unless it is absolutely necessary. If the ball has passed entirely through or if it can be felt under the skin, probing is unnecessary. Two great dangers attend the use of the probe,—infection and laceration of delicate structures, especially the brain. If probing is necessary, protect the wound with a sterile or clean dressing until perfect antiseptic precautions can be provided. Soldiers are provided with a first-aid package containing iodoform gauze and bandages, which they are instructed to apply to a wound until the surgeon can take care of it. In many cases no other treatment is needed and the wound heals without difficulty. A Nélaton's probe, which contains a tip of unglazed porcelain on which lead makes a mark when touched, may be used for lead bullets. Gird-

ner's telephonic probe is an ingenious electrical device in which the principle of the telephone is used for detecting a bullet. The Roentgen ray is invaluable as a means of locating balls or other foreign bodies buried in the tissues. As a rule, foreign bodies of any kind should be removed, although a ball may become encysted and be carried for years without giving trouble, but it is liable to cause neuralgia, sloughing of blood-vessels, or ulcerate into the bowels or bladder. The ball may be removed by forceps through the wound of entrance or an incision in the most convenient place. Search should always be made for foreign material, as bits of cloth, carried in by the bullet. After *hemorrhage* and *shock*, the greatest danger from gunshot wounds is *infection*. The preservation of life or limb often depends on the first treatment received after the infliction of a wound. Disinfect the surface, including the wound, but make no attempt to disinfect the interior of the wound; apply a sterile dressing and treat the wound as one in which primary union is expected. In extensive injuries, explore the wound carefully and cleanse and disinfect it before dressing.

Amputation and Excision.—The principles of modern surgery have saved many limbs and joints which would have been lost under the old régime. Simple penetration or perforation of a joint heals promptly and is seldom a cause for amputation. No attempt should be made to remove a ball from a joint unless it is easily accessible. If the wound is very large and a bone extensively shattered, an atypical excision may be done, simply removing the loose fragments and any tissues liable to slough. Drainage should be provided and the wound dressed aseptically and immobilized. Extensive shattering of a bone does not call for amputation unless complicated with a wound of the main artery and such destruction of the soft tissues as to render the establishment of collateral circulation impossible. In some of these cases resection of the injured portion of the artery might be done with end-to-end anastomosis. When in doubt let the decision be in favor of an attempt to save the limb. When amputation is necessary it should be done as soon as practicable after reaction, in the *primary period*, which includes the first 24 hours before the establishment of inflammatory fever. The *intermediate period* is the period of inflammation and lasts until the establishment of free suppuration. The period beginning with a subsidence of the symptoms of acute inflammation is the *secondary period*. Amputation should be done either in the primary or in the secondary period, the most unfavorable time being the intermediate period, during which no operation should be done unless absolutely necessary, as for septicæmia or traumatic gangrene.

REPAIR OF WOUNDS.

The *repair of wounds* is effected by a modification of the nutritive process in which the tissues to be repaired return to the embryonic state (see INFLAMMATION). Wounds heal in two ways: by *first intention* or *primary union* and by *second intention* or *granulation*. Union by *first intention* is seen in properly treated incised wounds in which there is no interference with the healing process. In such a wound the capillaries become thrombosed to the nearest collateral branch; there is free exudation of fluid, blood, lymph, and corpuscles; the fibrin

FIG. 1.—Section through skin of guinea-pig eight hours after a wound: *a*, the wound, filled with clot, the capillaries thrombosed on both sides; round-cell infiltration; *b c*, sweat-gland; *d*, hair-follicle. (Shakespeare.)

contained in this exudate coagulates on the opposed surfaces, binding them together. New vessels develop after the second day and shoot across through the lymph and cells, converting them into granulation tissue. The process goes on to the reproduction of normal tissue or to the development of scar tissue. *Healing by second intention* takes place when any interference with primary union occurs, such as loss of tissue, injuring the vitality of the wound edges, too much gaping, mobility, the presence of foreign bodies, too great tension of the flaps, improper temperature, or infection. Granulation tissue is formed and increases in amount, slowly filling up the wound to the level of the surface, scar tissue takes its place, and, gradually contracting, draws the edges of the wound together so that the epithelium has less space to cover. As the surface is reached, the pro-

liferating epithelial cells extend over the granulations as a bluish-pink line, until the whole surface is covered. If two aseptic granulating surfaces are brought together, union will often take place and the process of healing will be materially hastened—*healing by third intention.* It is merely a variety of the *second intention. Healing under a*

FIG. 2.—The same at a later stage. The clots in the capillaries almost removed, new vessels forming towards the gap, new connective-tissue spindle-cells replacing the round cells. The epithelium has united on the surface. (Shakespeare.)

scab is another form of healing by the second intention, the scar tissue being produced beneath a hard crust formed by the drying of blood and lymph from the wound. After the epidermis covers the wound the scab drops off. *Healing under a blood-clot* is still another form of healing by second intention, in which an aseptic blood-clot takes the place of a scab.

SHOCK.

Shock is a sudden depression of the nervous system and vital force, caused by injury or emotion. It is a frequent complication of wounds of the abdominal, cranial, and thoracic cavities, of crushing injuries of the limbs, and is sometimes seen after the most trivial injuries. It may be caused by physical conditions or by mental emotion, either independently of the other. It varies in degree from a scarcely perceptible form with slight pallor or sensation of nausea, to one of the most profound depression, ending in death.

Pathology.—The pathology is not well understood, but the nervous system is chiefly affected. According to Fischer, it is due to a reflex paralysis of the vascular system through the vasomotor nerves, as

a result of which the greater part of the blood accumulates in the abdominal blood-vessels, with anæmia of the heart, brain, skin, and other organs. This would explain the pale, cold skin, the weak, rigid muscles, the small, irregular pulse, and the nausea and vomiting—all symptoms of an insufficient blood-supply to the organs mentioned. Others regard the phenomenon as a reflex inhibition affecting all the functions of the nervous system, not limited to the vascular system; to a molecular disturbance of certain portions of the brain; to an irritation of the cervical cord, medulla, and the neighboring central structures; or to a powerful irritation acting directly upon the cord or indirectly through a peripheral sensitive nerve. Post-mortem examination shows the right side of the heart and great venous trunks distended with blood. Sometimes the heart is empty. The experiments of Hodge render it highly probable that certain physical changes would be found in the nerve centres, as the cells in the spinal ganglia of frogs and cats if subjected to electric stimulation for several hours, and of sparrows and bees after a hard day's work, have been found on microscopic examination to have undergone a marked change, the nucleus being smaller and jagged or irregular in outline instead of being smooth, and the protoplasm does not stain so well as when in a normal condition.

Causes.—Compound comminuted fractures, crushing injuries of the extremities, penetrating wounds of the viscera, severe hemorrhage, injuries to the testicle, blows on the neck over the pneumogastric nerve or larynx, or over the heart, or in the epigastrium over the solar plexus, severe or extensive burns, and lightning-stroke are common causes of shock. It is seen as a result of surgical operations, such as tapping the chest or abdomen, operations on the abdominal viscera, or sometimes even trivial operations, as the opening of a felon. There is no doubt that mental emotions—extremes of joy, fear, or sorrow—cause shock, which may even result in death. Age affects shock, either extreme of life being more susceptible to it. As to sex, women are less liable to it than men. Those of phlegmatic temperament stand shock better than those of sanguine and mobile temperament.

Symptoms.—The symptoms of shock are those of general depression or collapse. The surface is pale and cool, and may be covered by a clammy sweat. The pulse is feeble, rapid, and may be irregular; the respiration is shallow, rapid, irregular, and may be sighing; the temperature is subnormal; the face is altered in expression, appearing pinched, with sunken eyes, sometimes dilated pupils, pale lips, and a sickly white hue of the skin. Functional activity is generally diminished, the eyelids droop, the tongue is paralyzed, the

knees give way, and the sphincters relax. The normal secretions may be altered; milk in the breast has been known after a severe shock to become poisonous. The mental faculties may be more or less sluggish or apathetic; sometimes they are unnaturally acute. So-called *delayed* or *secondary shock* is in most cases fat embolism, concealed hemorrhage, or septic infection.

Reaction from shock is first indicated by returning color in the face and lips and improvement in the pulse. Often there is vomiting. The temperature rises to the normal point and there is a general improvement in the mental condition. Septic infection or toxæmia from the absorption of fibrin ferment may cause excessive reaction, with rise of temperature above the normal, mental excitement, and delirium. In some cases reaction fails to take place and the patient dies in coma.

Diagnosis.—Shock must be distinguished from *hemorrhage*, which it often accompanies or causes, from *concussion*, from *fat* or other *embolism*, from *syncope*, and from *septic poisoning*.

In *hemorrhage* there are great restlessness, thirst, dyspnœa, with sighing respiration and perhaps attacks of syncope. The mind is clear and the hæmoglobin is diminished. *Concussion* closely resembles shock, often coexisting with it, and it is sometimes impossible to distinguish between them. In *concussion* there is insensibility and the pulse is slow and full. The symptoms of *fat embolism* occur at a later period than those of shock, from twenty-four to forty-eight hours after an injury. The face is first pale, then cyanotic; the patient is excited and anxious; the heart's action is rapid and irregular; there is great dyspnœa, with rapid respiration, sometimes fifty or sixty to the minute; occasionally foam or blood is coughed up, and fat globules may be found in the urine. In *syncope* there is at first nausea, with perhaps dizziness and ringing in the ears, followed by partial unconsciousness of short duration. *Septic poisoning* may be distinguished from shock by the fact that the symptoms come on several hours after the receipt of an injury. There must be time for the formation of the toxin. According to Dennis, shock occurs within three hours, fat embolism within three days, and septic embolism within three weeks after injury.

Prognosis.—Shock may result in death in a few seconds, or the patient may die at the end of one or two days. Inability to swallow, insensibility of the conjunctiva, persistent vomiting, or relaxation of the sphincters indicates an unfavorable prognosis. A rectal temperature of 96° F. is a contraindication to any surgical operation. The prognosis is modified by the nature of the injury, whether a vital part is affected, as the brain, or serious injury to the abdominal

viscera or extremities, which entails a continued source of irritation and depression.

Treatment.—This may be *prophylactic* or *curative*. In surgical operations much can be done to prevent shock by encouraging the patient, by seeing that the operating room is warm, that the anæsthetic is not pushed too far, that the operation is not unduly prolonged, that delicate viscera are handled carefully and not unnecessarily, and hemorrhage prevented as far as possible. A hypodermatic injection of morphine and strychnine just before the operation, or a full dose of quinine two hours before the operation, have been used to prevent shock.

Curative.—General stimulation is indicated. Place the patient in a recumbent position, if not already so, with the head lowered. Apply heat to the surface by means of hot-water bags or bottles and warm blankets, and give alcohol, aromatic spirits of ammonia, or strychnine. When caused or accompanied by hemorrhage, give intravenous infusion of physiological salt solution, one drachm to the pint, at a temperature of 110° to 112° F. (43.3° to 44.5° C.). The quantity of the solution should at least equal the amount of blood lost. It may be used in cases where no blood has been lost, as it acts, probably, by filling the empty blood-vessels and heart, thereby stimulating the latter to more vigorous action. The quantity used varies from one pint to two or three quarts. It may also be given by hypodermoclysis (subcutaneous injection) or by the rectum.

FAT EMBOLISM.

Fat embolism is the plugging of small blood-vessels by minute drops of fat which have entered the circulation as a result of injury or disease.

Pathology.—Fat embolism is met with most frequently in the lungs as a result of comminuted or multiple fractures or after the crushing of soft tissues containing much fat. It may also occur after surgical operations, rupture of a fatty liver, or suppurative osteomyelitis. According to Park, it was found in ten per cent. of a series of two hundred and sixty miscellaneous dead bodies. It seldom occurs in children, because of the small amount of fat contained in their bones. Fat may enter the circulation through the thoracic duct, but probably seldom produces trouble in this way. It is usually taken up by the systemic veins and produces emboli in the lungs—the first set of capillaries with which it meets. Here it acts mechanically by plugging the capillaries and may even cause rupture with hemorrhage. If the globules of fat pass through the lungs they enter the general circulation and may produce embolism in the brain, spinal cord, kidneys, or liver.

Symptoms.—From twenty-four to seventy-two hours after injury, during which the patient may have been doing well, he becomes excited, the face pale and anxious, later cyanosed, with contracted pupils, and there is great dyspnœa, sometimes with cough and expectoration of foamy mucus, possibly tinged with blood. Respirations may be fifty or sixty to the minute; the pulse is rapid, but the temperature may not be disturbed; delirium, somnolence, and, finally, coma ensue, ending in death, probably due to the lodgement of the emboli in the brain.

Diagnosis.—Fat embolism must be distinguished from *shock*, the *effects of anæsthetics*, *acute congestion of the lung*, and *cerebral hemorrhage*. *Shock* may be excluded, as it comes on at an earlier period—with the receipt of the injury. From the *effects of ether*, which may produce congestion of the lungs and kidneys, it is with difficulty distinguished and the two conditions may occur together. The discovery of fat globules in the urine is pathognomonic, but care should be taken to exclude the possibility of fat which may have been used on a catheter. The symptoms of *cerebral hemorrhage* are similar to those of fat embolism of the arteries of the brain; the latter, however, is preceded by dyspnœa and other evidence of interference with the pulmonary circulation.

Prognosis.—The prognosis depends on the amount of fat which has entered the circulation, the possibility of its continued entrance, and the strength of heart necessary to force the emboli through the pulmonary circulation. When death occurs it is usually within from eighteen to forty-eight hours. In some cases serious trouble may follow at a later date from interference with the circulation in the brain or spinal cord, which may cause paralysis.

Treatment.—Stimulate the heart by means of alcohol, strychnine, or digitalis. Park advises inhalations of oxygen for the purpose of oxidizing the fat in the lungs and to prevent asphyxiation. As preventive measures the parts which have been crushed or broken should be handled gently and immobilized, in order to prevent as far as possible the breaking up of the fatty tissues. Provision should also be made for drainage.

CHAPTER III.

EFFECTS OF EXTREMES OF TEMPERATURE AND OF ELECTRICITY.

BURNS AND SCALDS.

A *burn* is an injury of the tissues caused by contact with dry heat, while a *scald* is an injury resulting from contact with hot or boiling liquids or steam. Certain chemical agents, as strong acids and alkalies, produce injuries which may be classed under either head.

Classification.—According to Morton, burns are divided as follows: *Burns of the first degree*, in which there is redness of the skin, perhaps with hyperæmia and swelling, but without vesication. *Burns of the second degree*, in which there is an exudate of serum which raises the cuticle from the cutis, forming vesicles or bullæ. *Burns of the third degree*, which include all those which affect the deeper tissues, from destruction of the true skin to that of the cellular tissue, muscles, and bone.

Pathology.—Burns and scalds are commonly caused by setting the clothes on fire, by coming in contact with a red-hot stove, molten metal, boiling water or steam, a conductor, as wire charged with electricity, lightning-stroke, concentrated acids and alkalies, and explosions of gunpowder or inflammable gases. Sunburn may also be named. The post-mortem appearances are not characteristic, but certain theories have been advanced in explanation of the rapidly fatal shock, namely: (1) The destruction of the red blood-corpuscles, leading to the death of the white corpuscles from the excessive amount of hæmoglobin. This causes an excess of fibrin ferment, which produces coagulation of the blood in the vessels. The basis of this theory is the finding of necrotic areas and an excess of hæmoglobin in the kidneys, with the symptoms of anuria so often observed in these cases. (2) Overheating of the blood, causing paralysis of the heart. (3) Excessive irritation of the nervous system, with resulting reflex diminution of its vascular tone. (4) Poisoning from ptomaines produced by the burning of the tissues. It is said that hydrocyanic acid is formed by the action of heat upon substances in the skin. Œdema of the glottis may result from scalds of the mouth or the inhalation of steam.

Symptoms.—The symptoms depend on the situation of the burn, its

degree, and the extent of surface involved. *Pain* is often greatest in superficial burns of small area, while it may be completely absent in the worst cases. In deep burns, or those covering a large area, even if superficial, *shock* is marked, *thirst* pronounced, the pulse rapid and thready, the temperature subnormal, the respiration hurried, the skin cold and clammy, and great prostration exists. Rigors, cramps, and, in children, convulsions may occur. The mind is usually clear, but in fatal cases delirium comes on, followed by death in coma. Should the patient survive the first twenty-four or-forty-eight hours, symptoms due to inflammation or the absorption of decomposed products arise. Congestion or inflammation of the brain, lungs, kidneys, or intestines may supervene; albuminuria is a common symptom. After the second week septic conditions may arise, and pyæmia, tetanus, amyloid changes, or hemorrhage may carry the patient off. Gastric or duodenal ulcer is a curious complication which occasionally occurs. According to Moullin, duodenal ulcer was found in sixteen out of one hundred and twenty-five cases. It occurs as early as the fourth day, but is most frequent in the second and third weeks. It is not connected with Brunner's glands, and is probably due to the action of the gastric juice on a mucous membrane which has been deprived of its circulation by embolism. Duodenal ulcer may give no symptoms; or there may be diarrhœa, vomiting of blood, with pain and tenderness in the epigastrium, or sudden peritonitis from perforation. As sequelæ of burns, the patient may be afflicted with cicatrices, causing great deformity, or annoyance by ulceration, or the development of epithelioma in the scars.

Prognosis.—This depends on the age and health of the patient and on the degree and the area of surface affected. Burns of the third degree, even of limited extent, occurring on the thorax or abdomen or other important regions, are apt to prove fatal. Burns of the first degree involving one-third of the surface are usually fatal, death resulting within twenty-four hours from shock. Later death may result from septicæmia, secondary hemorrhage, or peritonitis from perforating ulcer of the duodenum.

Treatment.—The treatment is *constitutional* and *local*. In severe cases the most urgent indication is the treatment of shock. Stimulate with ammonia, alcohol, or strychnine, and the application of heat to the surface. Opium may be necessary. Intravenous infusion of salt solution is of great service.

Local Treatment.—In burns of the first or second degree involving a small area, apply gauze saturated with solution of bicarbonate of sodium. If ulceration follow, use antiseptic dressings with ointment of oxide of zinc, carbolic acid, or iodoform. Carron oil may

be used for burns of the first degree of limited extent. It is sometimes necessary to anæsthetize the patient in order to dress the injury. Where a large portion of the surface is involved the continuous water bath is the best and most comfortable local treatment. The part, if a limb, or the entire body up to the neck, may be kept immersed in a bath of 100° F. (38.8° C.) for an indefinite period. Œdema of the glottis requires scarification of the epiglottis or tracheotomy.

Scars resulting from burns may require plastic operations for their relief. They may often be prevented by skin-grafting the ulcers during the healing process.

FROST-BITE.

The effects are similar when either extreme of temperature is applied to the tissues of the body, but in the case of *cold* they come on more slowly and are accompanied by less pain than in burns. Parmenter divides frost-bites into three degrees, corresponding to the classification of burns and scalds,—frost-bites of the *first* degree, with simple redness or erythema; of the *second* degree, with vesication; and of the *third* degree, with more or less destruction of the deeper tissues. *Chilblain* and *pernio* are names given to the first degree of frost-bite, especially after it has occurred several times.

Pathology.—Extreme cold first stimulates and then arrests the circulation. This is followed by the escape of serum and corpuscles from the vessels, with swelling. If the exudation of serum is sufficient, the cuticle may be separated from the cutis and blisters or blebs are formed. In the severest frost-bites or freezing, arrest of the circulation extends to the deeper structures, and thrombi form in the veins; the part becomes anæsthetic, blue in color, then white and hard like marble, and gangrene is apt to follow. The parts most frequently affected are the ears, nose, fingers, and toes, or the entire foot, hand, or extremity.

Symptoms.—The symptoms may be local or constitutional.

Local Symptoms.—There are first *numbness* and *tingling* and finally *loss of sensation* in the part affected, which changes from red to *white* and is *cold* to the touch. When reaction takes place, the parts become swollen and red, with a burning pain; or, if hopelessly injured, they shrivel up and contract. In *chilblain* there are *itching* and *burning*, which may last for several days, followed by desquamation of the cuticle. If gangrene occur, it will be found on reaction that the local circulation does not return, the part remains cold and pulseless, with complete loss of sensation; in a few days or a week the skin changes to a bluish color, which becomes darker, the parts shrivel, and a line of demarcation forms.

Constitutional Effects.—These are at first stimulating, the force and frequency of the heart's action being increased. This is followed by a general feeling of discomfort, uneasiness, numbness, drowsiness, with an almost irresistible desire to sleep, which, if yielded to, results in death from congestion of the viscera. Sudden chill is said to produce death by cerebral anæmia, prolonged exposure by cerebral congestion, while sudden reaction from exposure to warmth produces death by embolism.

Treatment.—The object is gradually to restore the circulation to the parts without producing too sudden reaction, which would be followed by inflammation. It is customary in cold countries, when the nose or ears are threatened with frost-bite, or even after its occurrence, to rub the part vigorously with snow. Place the patient in a cool room and rub the parts gently with ice or snow until circulation returns. Nothing warm must come near the frozen part. After reaction continue rubbing, expose the parts to the air for a while, and apply a dressing of cotton. The limb should be kept elevated, and the air of the room very gradually and cautiously warmed. In *chilblain*, which sometimes becomes chronic, the circulation being feeble and sluggish, stimulating applications are indicated, as alcohol, tincture of iodine, or soap liniment. The *acute* form should be treated by gentle friction with snow or the application of ice-water. If the feet become cold, do not warm by the fire, but bathe them in cold water and rub dry with a towel.

Constitutional treatment is conducted on the same principle, the patient being placed in a cool room and the body sponged or bathed with cold water, which may be gradually raised in temperature from 60° to 90° F. Give stimulants cautiously, preferably in cold water by the mouth, or subcutaneously.

EFFECTS OF ELECTRICITY.

Injuries from electricity may result from *lightning-stroke*, from contact with the conductors of electrical apparatus, or from exposure, under certain conditions, to the Roentgen ray. Lightning-stroke may be *direct*, as when the current passes directly through the body; or *indirect*, when it strikes a neighboring body, causing shock to the person standing near. The effects of natural and artificial electricity are the same, and depend, probably, on the strength of the current.

Symptoms.—A stroke of lightning may produce instantaneous death, with or without visible laceration of the body. Fractures and partial or complete avulsion of the extremities have been produced. In non-fatal cases shock is a prominent symptom, and *unconsciousness* or *coma*, lasting from a few hours to several days, may

result. On return of consciousness paralysis may appear, as anæsthesia, hemiplegia, or loss of vision. This may be the result of hemorrhage in the brain or spinal cord and is sometimes permanent. Peculiar marks are sometimes left on the body, probably due to electrolysis, with deposit in the skin of the coloring matter of the blood. Severe burns occur and may be long in healing.

Roentgen-Ray Burns or Dermatitis.—The macroscopical appearances of an injury from the Roentgen ray are in no wise different from those of a burn or scald, and may be of any one of the three degrees of burn. The first *symptoms* appear from the second to the fourth day as *redness* and *swelling* of the skin, followed by *vesication*, peeling of the cuticle, and in severe cases also of the cutis and subcutaneous connective tissue. There is little or no *pain* connected with this ulceration. Such a case occurred in the writer's practice, in which an ulcer four by six inches formed on the abdomen, destroyed all the tissues down to the muscles, and required over a year to heal.

Treatment.—The treatment of *shock* from lightning-stroke, or electricity in any form, should be on general principles. Give stimulants, as strychnine, ammonia, or alcohol, and morphine for the relief of pain. Ulcers should be treated aseptically and care taken to prevent infection.

CHAPTER IV.

OPERATIVE SURGERY.

A *surgical operation*, broadly defined, means any work with the hand, with or without instruments, for the purpose of relieving a patient of injury or disease. By common consent, however, the word *operation* is usually understood to mean interference which involves the use of instruments, especially the knife.

ASEPSIS AND ANTISEPSIS.

These words, often erroneously used as synonymous, have about the same difference in significance as the prevention and the cure of putrefaction or infection.

An *aseptic* operation is one performed through uninfected tissues, in which the instruments, sutures, and dressings are sterile and the skin over the region to be operated on has been disinfected. It is true that antiseptics are needful in preparing for an aseptic operation, but after thorough preparation only sterile or aseptic articles are used and there is no further necessity for antiseptics. An *antiseptic* operation is one in which antiseptics or germicides in the form of spray or solution are employed during the operation, on account of the tissues being already infected. In the one case, *asepsis*, the object is to prevent or keep out infection, while in the other, *antisepsis*, the object is to destroy the infection which has already obtained a foothold. An *osteotomy* for bowlegs would be an aseptic operation, while a *sequestrectomy* on account of *osteomyelitis* would be an antiseptic operation. Often the two are combined,—for example, exposing an abscess in the skull by an aseptic operation, then destroying the infection by the use of antiseptics.

Antiseptics.—The following antiseptics or germicides are those most commonly used. Moist heat of 212° F. for five minutes will destroy the germs and spores of the hardiest bacteria. Of solutions more or less germicidal according to their strength : bichloride of mercury, 1 to 10,000, to 1 to 1000 ; carbolic acid, 1 to 40, to 1 to 20 ; peroxide of hydrogen, with equal parts of water, or in full strength ; formalin, 1 to 2000, to 1 to 500. Iodoform, which is largely used in dressing wounds and medicating dressings, while not a germicide, is useful by inhibiting the growth of germs.

STERILIZATION OF INSTRUMENTS.—All instruments used in an operation must be sterilized, and the best method is to boil them for ten minutes in a one per cent. solution of crystalline carbonate of sodium. The sodium salt is to prevent rusting. Knives and sharp-pointed instruments should be wrapped in cotton to protect the edges. The instruments should be composed entirely of metal, as wood or rubber is damaged by boiling. The instruments may be boiled in an ordinary tin vessel, or in the apparatus of Schimmelbusch, which consists of a small gas stove containing water in which a wire tray containing the instruments is set. After sterilizing the instruments they are placed in trays of metal, glass, or porcelain containing a warm sterile solution of sodium carbonate until used in the operation. Rubber instruments, as catheters and bougies, are sterilized by exposing them to steam for ten or fifteen minutes, to formaldehyde vapor, or they may be soaked in a three per cent. solution of formalin and glycerin for twenty-four hours. After the operation the instruments should be cleansed by means of soap and water and a brush, resterilized, dried, and put away.

STERILIZATION OF LIGATURES AND SUTURES.—The materials in common use as ligatures and sutures are silk, silkworm gut, catgut, kangaroo tendon, horse-hair, and silver wire.

Silk comes in different sizes, either plaited or twisted. It is sterilized by first winding it on glass spools, or cutting it in lengths of about one yard each and wrapping them separately in bits of cloth, then boiling them for half an hour in a solution of bichloride, 1 to 500, or subjecting them to steam for an hour. Silk sutures are slowly absorbed, except the knots, which may last many months.

Silkworm gut, made from the chrysalis of the silkworm, comes in bundles of stiff threads. It is sterilized by subjecting it to steam or boiling water for half an hour and may also be soaked in carbolic solution, 1 to 20, for fifteen minutes. Silkworm gut is used only for sutures. It is unabsorbable, and resembles silver wire in its non-irritating qualities and resistance to infection.

Catgut.—Next to silk catgut is more generally used for sutures and ligatures than any other material. On account of its easy absorbability it is the favorite material when buried sutures are needed. It may be absorbed too soon or become untied and secondary hemorrhage follow. Catgut, being composed of the submucosa of the sheep's intestine, is difficult to sterilize. Catgut may be prepared for use by one of the following methods:

1. *Wyeth's Method.*—Soak the catgut, as purchased in the form of violin-strings, in benzine for six days, or in Squibb's ether for four days, to remove the fat. If benzine is used, wash the catgut in pure

ether until all traces of benzine have been removed. "Transfer the catgut to a clean, wide-mouthed bottle filled with absolute alcohol, and boil in a water-bath for four hours, as follows: Place a folded towel in the bottom of an ordinary boiler and stand the bottles on this. A toothpick or bit of wood should be put alongside the stopper to give vent to the alcohol vapor and prevent explosion. The water in the boiler need not be more than three or four inches in depth. As alcohol boils at about 170° F., it is not necessary to bring the water to the boiling point. The bottle should be sealed when cool, and the catgut is kept in the absolute alcohol." Another method is to boil the catgut in alcohol under pressure. This is done by selecting a heavy metallic jar, with accurately fitting top held in place by a strong clamp and screw. The jar is partly filled with absolute alcohol, the catgut put in on spools or skeins, the top of the jar securely fastened, and the jar is then placed in water so that it is completely covered, and boiled for one hour.

2. *The Cumol or Krönigs Method.*—As described by McBurney, the cumol method is as follows: "Cumol is an inflammable but unexplosive hydrocarbon with a boiling point of about 170° C. When the cumol fluid is brought to a temperature just short of its boiling point, all spores introduced into it are destroyed, as a higher temperature is reached than when alcohol is used, and there is no waste of cumol, as the fluid is kept below its boiling point. The catgut is rolled upon glass spools, and these are put into a glass beaker. The beaker stands in a sand-bath heated with a Bunsen burner. A layer of cotton should be placed at the bottom of the beaker, on which the catgut may rest; the top of the beaker is to be covered with a piece of cardboard. Through a hole in the centre of the cardboard a thermometer passes. Heat is now applied to the sand-bath, and the temperature of the catgut slowly raised to 80° C. In this manner all moisture is driven out of the catgut. This degree of heat is maintained for one hour. Cumol at a temperature of 100° C. is now added to the beaker, completely covering the catgut. The temperature is then increased to 165° C., and is kept at that point for one hour. The fluid is now poured off, and the catgut is allowed to dry in the beaker on the sand-bath at a temperature of 100° C. for two hours. It is then to be transferred to sterile jars or test-tubes until needed; or it may be preserved in sterile alcohol."

Chromicized Catgut.—To render the catgut less absorbable it may be *chromicized* by first washing it in ether, to free it from fat, then soaking it for twenty-four hours in a four per cent. solution of chromic acid in water. It may then be prepared by the cumol method.

3. *The Formalin Method.*—Tillmanns' method is as follows: Soak

the raw catgut from twelve to forty-eight hours, according to size, in four per cent. formalin. Wash off with running water for from twelve to twenty-four hours, then boil the catgut in water fifteen to twenty minutes, place in absolute alcohol for six hours, and keep in oil of juniper.

4. *Boeckman's Method.*—Wrap the catgut in paraffin paper, seal it in an envelope, put it in a sterilizer, and expose it to dry heat at 284° F. for three hours and to 290° F. for four hours. The catgut is kept in the envelope and paraffin paper until wanted for use.

Catgut is numbered from 0 to No. 12, which is the coarsest. The numbers most frequently used by the surgeon range from 0 to 4, and occasionally 00, a still finer thread, may be needed.

Kangaroo Tendon.—This material, obtained from the tendon of the tail of the kangaroo, is popular as a suture in the operation for the radical cure of inguinal hernia. It has an advantage over catgut in not being absorbed so soon, and thus gives more time for the union of the structures which have been sewed together. It is prepared in the same manner that catgut is prepared.

Other absorbable animal materials used as ligatures are buckskin, ox aorta, nerve, and tendon.

Horse-hair.—Horse-hair makes a very good suture for external use, resembling silkworm gut. It is unabsorbable, and is prepared by washing with soap and water, then sterilizing by steam under pressure for one hour.

Silver wire is used as a suture chiefly for uniting broken bones, and occasionally as an external or subcuticular suture. It is prepared by heating in an alcohol flame, or by boiling in a one per cent. sodium carbonate solution with the instruments.

STERILIZATION OF DRESSINGS.—Various materials have been used for surgical dressings, including oakum, jute, wood-wool, moss, cotton, and gauze. At the present time absorbent cotton and gauze are almost exclusively used.

Absorbent cotton is bought in the form of rolls of thin sheets, but it should be sterilized before using by placing it in an autoclave and heating it under pressure for one hour.

Gauze, or *cheese-cloth*, is prepared by taking a bolt of cheese-cloth, cutting it into convenient lengths, boiling it for two or three hours in water, then rinsing in cold water and soaking for twenty-four hours in a twenty per cent. solution of chlorinated soda. Rinse in clear water, dry, and fold away until convenient to sterilize. For sterilizing, cut into lengths of from one to two yards, fold up and pin in towels, place in a sterilizer (autoclave), and submit to ten pounds' pressure of live steam for half an hour. Steam is then shut off from

the sterilizer, but allowed to continue without pressure in the jacket for half an hour in order to dry the dressing. This process can be repeated, if thought necessary, on the following day or subsequently.

Bichloride gauze is made by dipping clean sterilized gauze in a 1 to 1000 solution of bichloride, then squeezing as dry as possible before using. *Iodoform gauze* may be prepared by rubbing iodoform powder into the meshes of the sterilized gauze; or it may be dipped into a mixture of iodoform prepared as follows, as recommended by McBurney: Take half a pound of iodoform powder and mix it with four ounces of glycerin. To this add two litres of thick soapsuds and stir them well together. To this mixture add two litres of 1 to 20 carbolic acid solution. This quantity is sufficient to impregnate thirty yards of gauze.

This iodoform gauze is sterilized as follows: The gauze, cut into strips of suitable width and length, is put into glass ignition tubes (thick, strong tubes) and the mouths are plugged with cotton. These tubes are put into a wire basket, placed in the sterilizer, and submitted to steam sterilization under pressure for half an hour in the manner already described.

PREPARATION OF THE OPERATING ROOM.

The operating room should be of good size, well heated, lighted, and ventilated, and should receive the light from the south. It should be situated in the highest part of the building, as germs are less numerous at high altitudes. For night work electric light should be supplied in abundance. The floor should be composed of cement or tiling and the walls and ceiling of material which can be easily washed. The furniture of the operating room should include an operating table composed of metal and glass, of simple construction, but one which permits rapid lowering of the head and placing the patient in the Trendelenberg position. Two other tables of metal and glass should be provided, one for holding dressings and instruments, the other for basins for solutions during the operations; also a couple of large buckets for slops, rejected sponges, etc., an irrigator on a stand, and an apparatus for the infusion of salt solution into the veins or by hypodermoclysis. The temperature of the room should be between 75° and 80° F. The sterilizers, instrument case, and apparatus for bathing should occupy a communicating adjacent room and another room should be employed for anæsthetizing the patient. The operating room should always be prepared by thorough disinfection before being used for operations. For this purpose formaldehyde gas may be supplied by means of a generator and the floor should be scrubbed with solution of bichloride, 1 to 1000.

PREPARATION OF THE OPERATOR.

The surgeon and his assistants should be properly prepared, to avoid all chance of infecting the patient. It is well to exchange the outside clothing for suits of white cotton which have been sterilized. The hair of the surgeon and assistants should be enclosed in a head-dress of cotton cloth or a cap, to prevent dust from the hair dropping into the wound or on the dressings, and if the operator has to talk during the operation it is well to have a piece of gauze or a mask of some kind over the mouth.

Disinfection of the Hands.—There are several processes in use for disinfecting the hands, none of which can be absolutely depended on in every case: 1. Trim and cleanse the nails of all visible dirt and scrub the hands and forearms as high up as the elbows in soap and warm water with a sterilized brush, next in fifty per cent. alcohol, in order to remove fatty substances, and then scrub for two or three minutes in a warm 1 to 1000 bichloride solution. The bichloride solution may be removed by washing in sterile water. 2. *Stimson's Method.*—The hands and arms are washed with soap, water, and brush, and a tablespoonful of chlorinated lime moistened with enough warm water to make a thick paste is thoroughly rubbed into the fingers, especially about the nails and over the hands and forearms. A piece of carbonate of sodium about an inch square and half an inch thick is moistened with water and rubbed over the hands in the same manner. The hands are next rinsed in sterile water and then in a 1 to 500 solution of aqua ammoniæ to remove the odor of chlorine. 3. *Welch's Method.*—Prepare the hands with soap, water, and brush as described, then soak in 1 to 500 bichloride solution, wash again in simple water, then immerse for one or two minutes in a warm saturated solution of permanganate of potassium, then in warm saturated solution of oxalic acid until decolorized, after which wash them in sterile salt solution and immerse for two minutes in sublimate solution, 1 to 500. Methods 2 and 3, if used frequently, are almost sure to produce a painful dermatitis. 4. Roswell Park uses flour of mustard. The hands are first prepared in the usual way by means of soap, water, and brush, and then throughly rubbed with a quantity of mustard flour moistened with cold water. This leaves the skin of the hands in a soft, pliable condition.

Rubber Gloves.—Rubber gloves are quite generally used both as a protection to the patient and in septic cases as a protection to the surgeon and assistants. The rubber gloves can be sterilized, while with the naked hand there is always some doubt as to its sterility. The gloves are prepared by washing them with soap and water

and then boiling them for fifteen minutes in a one per cent. solution of carbonate of sodium. Before using the gloves the hands are prepared by one of the methods described, in order to prevent the possibility of infecting the patient in case the glove should be torn or cut during the operation. The gloves are convenient, as they may be kept sterilized and used at times when sterilization of the hands may be impossible. It is a good rule for the surgeon to have his assistants use gloves, as otherwise he cannot always be sure that their hands are suitably prepared.

PREPARATION OF THE PATIENT.

When possible, operations should be performed early in the morning, as the patient is then in good condition after a night's sleep, and is relieved from the anxiety of waiting during the day for the operation. The patient, having made up his mind to submit to the operation after a candid statement of his condition and the prognosis, should be encouraged as much as possible to expect a favorable result, and thus avoid the depressing influence of despondency. The heart, lungs, blood, and urine should be examined, in order to determine the propriety of operating and the anæsthetic which should be selected. If an operation is imperative, other things being equal, chloroform is to be selected for anæsthesia in renal and pulmonary diseases and ether in cardiac lesions. If the hæmoglobin is below 50 per cent. or the urea is less than 50 per cent., no anæsthetic should be given, unless an operation is imperative. The patient's bowels should be freely opened on the day preceding the operation; he should be given a thorough bath, and the field of operation prepared by washing with soap and water, shaving, and applying a sterilized soap or antiseptic dressing. The next morning, just previous to the operation, the parts should be again scrubbed and washed with alcohol and solution of bichloride 1 to 1000. Do not excoriate by rough scrubbing or the prolonged use of the soap poultice on a delicate skin. The soap poultice may be used in the form of soft soap spread over the part where the skin is scaly and hard, as in the scalp, or gauze may be dipped in a solution of soap made weaker or stronger, as the case may require. During the operation the patient should not be unnecessarily exposed to cold, all parts except the field of operation being wrapped in blankets, and the extremities enclosed in sleeves or leggings. A sterile sheet should be placed over the patient, covering the entire body with the exception of the field of operation. Sterilized towels may be used in place of a sheet, but, unless pinned together, are apt to slip.

CHAPTER V.

ANÆSTHESIA.

ANÆSTHESIA means *loss of sensation*, and may be general or local. In general anæsthesia sensibility or consciousness as well as sensation is lost.

GENERAL ANÆSTHESIA.

History.—The first surgical operation under general anæsthesia was performed in 1842 by Dr. Crawford W. Long, of Athens, Georgia, but it was not until after its public administration by W. T. G. Morton and J. C. Warren, October 16, 1846, that anæsthesia was generally adopted. In both the cases mentioned ether was the anæsthetic. In 1847 James Y. Simpson, of Edinburgh, introduced chloroform as a general anæsthetic in surgical practice. The general anæsthetics most frequently used are ether, chloroform, and nitrous oxide gas.

ETHER.—Ether, or sulphuric ether, made from alcohol and sulphuric acid, is the oxide of ethyl, with the formula $(C_2H_5)_2O$. Pure ether is a clear, colorless, volatile liquid, of pungent odor, and at

FIG. 3.—Allis's inhaler for the administration of ether.

a temperature of 59° F. has a specific gravity of .718. It boils at 95° F. The gas is highly inflammable and is about two and one-half times heavier than air,—two facts important to remember in operations where lighted candles or gas are used. If the light is kept well above the ether, the danger of ignition is very much diminished. Pure ether remains clear when a little copaiba is added. Ether should be kept in tin cans in a cool, dark place.

Administration.—Ether may be administered by means of special inhalers, as those of Allis and Ormsby, or in the absence of these by means of a towel folded in the shape of a cone, with enough paper to keep it stiff and prevent evaporation. Allis's inhaler seems to be

ANÆSTHETIC CHART.

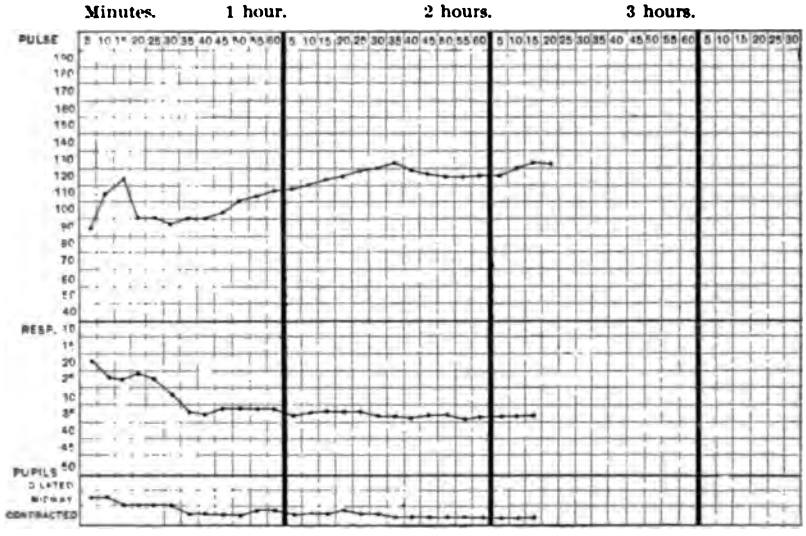
Emergency Hospital.

Name of patient *M. W.* Ward Bed Date *April 26* 19*02.*

Operation *Resection and anastomosis of colon for carcinoma.*

Anæsthetic *ether*. Amount to anæsthetize grams. Total amount grams.

Duration of administration *9 to 11.30 A. M.*



Stimulants *none.*

Vomiting during or after *slight, after operation.*

Remarks *15 minutes to complete anæsthesia.*

Sutton
Anæsthetizer.

the most popular; it is made of hard rubber or metal and contains a metallic framework, upon which are placed a number of folds of a bandage, upon which the ether is poured without removing it from the face of the patient, and air is admitted freely with the ether.

The anæsthetic should be given quietly, without noise or excitement of any kind. About one drachm of ether is poured into the inhaler, and the latter is placed over the nose and mouth of the patient, who is requested to breathe naturally, and thus avoid coughing. The ether is gradually increased as the patient becomes accustomed to it, until unconsciousness results, which usually occurs in from five to twenty minutes. The first effect of ether is to produce irritation of the mucous membrane of the larynx and trachea, with cough. This soon passes off, and is followed by the stage of primary anæsthesia, which lasts only for a minute or two. The face is flushed, the respiration hurried, and the pulse somewhat accelerated and stimulated. A period of excitement comes on, in which the patient struggles, becomes rigid, and sometimes talks, laughs, or sings. This stage passes into one of complete unconsciousness and of insensibility to pain, with deep, regular respirations, often accompanied by snoring, flushed face, moist skin, and general muscular relaxation. The pupils are slightly contracted. The snoring and general muscular relaxation are sufficient evidence that the patient is ready for the operation, and the anæsthetizer should not put his finger in the eye in order to test the conjunctival reflex, as inflammation of the conjunctiva is sometimes produced by such practice. Ether is at first a stimulant, but later on it acts as a depressant.

Complications during Etherization.—Sudden arrest of respiration, the patient's face at the same time becoming cyanosed. The cone should be removed for a few seconds, and if the patient does not breathe pressure should be made upon the chest, in order to excite respiration. Frequently the patient stops breathing, simply holds his breath as if resting, but the face is not cyanosed, and this condition need cause no apprehension.

Excessive Secretion of Mucus.—The irritation of the bronchial tubes may cause such a secretion of mucus as almost to asphyxiate the patient. When this occurs the head should be turned to one side and the mouth held open so that the mucus can escape, and the pharynx should be sponged at frequent intervals to clear it of mucus.

Asphyxiation may be caused by falling backward of the tongue from complete muscular relaxation. This may be relieved or prevented by keeping the patient's lower jaw pressed forward by the fingers behind the angles of the bone. In some cases it is necessary to draw the tongue forward with forceps.

Vomiting.—Vomiting is not apt to occur unless the patient has partaken of food within three or four hours previous to the operation. There is great danger, unless proper care is exercised, that the

food will pass into the larynx and trachea and suffocate the patient. If vomiting occurs, remove the anæsthetic, turn the patient's head to one side, and lower it so that the matter can easily escape from the mouth. If the vomited matter enters the trachea, producing asphyxiation, perform tracheotomy. If the stomach is empty, vomiting is often relieved by pushing the anæsthetic.

Respiratory Failure.—Respiratory failure may be caused by paralysis of the respiratory centre or spasm of the respiratory muscles. The patient suddenly stops breathing, the skin becomes cyanosed, and after a few minutes, unless respiration is restored, the heart ceases to beat. For such complication the head should be lowered, the mouth opened, the tongue drawn forward, and artificial respiration established. Sylvester's method may be used, by which the surgeon grasps the arms just above the elbows and draws them outward and upward until they are above the patient's head. They are held in this position for about two seconds while the air is entering the lungs. The arms are then lowered and pressed against the side of the chest for two seconds, during which time the chest is emptied as in normal respiration. These movements should be made twelve to fifteen times a minute. Or the method in use by the United States Life Saving Service for restoring the apparently drowned may be used, modified to meet the exigencies of the case.

Laborde's Method.—It is claimed that Laborde's method will sometimes restore respiration in apparently hopeless cases. It is practised as follows: The tip of the tongue is grasped and drawn out of the mouth to its full extent, regularly, sixteen times a minute.

After Effects.—The most common of the disagreeable after effects of taking ether are *nausea and vomiting*, lasting only an hour or two, or sometimes twenty-four to thirty-six hours. For its relief nothing should be given by the stomach except small quantities of crushed ice with brandy or champagne. Good results have been obtained from small quantities of hot water or of cocaine one-quarter of a grain, administered by the mouth. *Congestion of the kidneys, albuminuria,* and *suppression of urine* may follow ether anæsthesia. The treatment consists in giving plenty of water as a diuretic, keeping the patient warm in bed, and inducing free action of the skin. *Pneumonia or bronchitis* may follow the administration of ether, directly or within three or four days, the irritating effects of the vapor predisposing to the location and development of pathogenic organisms in the respiratory organs.

CHLOROFORM.—Pure chloroform, made by the distillation of alcohol with chlorinated lime, is the trichloride of methyl ($CHCl_3$), a clear, colorless, volatile liquid of sweetish taste and pleasing ethereal

odor, boiling at 141.8 F., specific gravity 1.502 at 55° F., and its vapor is slightly inflammable and a little more than four times as heavy as air. It should be kept from the light in dark glass bottles, as the light decomposes it into hydrochloric acid and chlorine. This may be prevented by the addition of from ½ to 1 per cent. of absolute alcohol. Only pure chloroform should be used. A rough test may be made—Hepp's smelling test—by dipping a piece of pure Swedish filter-paper into the chloroform and allowing it to dry. If the chloroform is pure the dried paper has no odor, but if there is a peculiarly sharp, irritating odor, the chloroform is impure.

Physiological Action.—Chloroform vapor enters the blood through the lungs and probably forms a chemical combination with the hæmoglobin of the red blood-corpuscles, destroying them or crippling them in their oxygen-carrying functions. Both ether and chloroform produce leucocytosis and diminish the hæmoglobin; hence they should not be used in cases in which the hæmoglobin is less than fifty per cent. There is a decrease in oxidation, the blood becoming more or less venous, the arterial tension is reduced—probably from action on the vasomotor centres—and the temperature of the body is diminished.

Respiration is affected by direct action on the respiratory centre, first in the way of *stimulation*, later *depression*, and paralysis may result. The heart's action may be affected in two ways: First, by *stimulation* of the inhibitory action of the pneumogastric nerve on the heart by means of irritation of some of the branches of the fifth nerve, causing a slowing or arrest of the heart's action. This may occur early in narcosis and is probably the explanation of sudden death occurring from extraction of teeth during chloroform anæsthesia. Second, there is probably a direct action upon the heart *muscle* and its *ganglia*, producing depression or paralysis. The *central nervous system* is affected chiefly through its ganglion cells. The sensory or higher functions located in the cerebrum are first affected, then the cerebellum, and finally the spinal cord, the medulla oblongata retaining its functions to the last.

Chloroform is excreted by the urine chiefly in the form of chlorides, also by the lungs, and is found in the milk of nursing women.

Administration.—Prepare the patient according to the method given for the administration of ether. Keep the room moderately warm,—about 75° F. Remove all loose articles, as false teeth, plates, tobacco, or candy, from the mouth, anoint with vaseline the skin around the mouth and nostrils, and cover the eyes with a folded napkin to prevent irritation. Chloroform is best administered by means of Esmarch's inhaler, consisting of a wire frame covered with a porous woollen cloth which can be exchanged at any time

for a clean one. The frame fits over the nose and mouth and the chloroform is dropped from a "chloroform dropper," which is a bottle fitted with a cork containing two small tubes, one of which extends into the bottle just below the end of the stopper and projects about an inch and a half above and is bent at an angle. Through this the chloroform is dropped upon the mask. The other tube extends about half an inch above the stopper, but projects below to a point about half-way to the bottom of the bottle, and through this tube air is admitted to enable the chloroform to drop from the other tube. This can be regulated by pressure with the finger on the end of the tube. In the absence of a special apparatus a folded napkin held about half an inch above the nose and mouth may be used. With the inhaler in position the chloroform is poured, drop by drop, on the inhaler opposite the patient's nose and mouth, slowly at first until he becomes accustomed to the vapor, then more rapidly. By this method an abundance of air is provided with the chloroform vapor. The patient should always be in the recumbent position. The anæsthetizer should carefully and constantly watch the pulse, the respiration, and the pupils. A mouth-gag, forceps for seizing and drawing out the tongue, and a hypodermatic syringe loaded with strychnine sulphate and atropine should be at hand. The arms of the patient should be placed in such a position as to prevent undue pressure on the musculospiral nerves,—either across the patient's chest or by the side of the body. At first the pupils dilate slightly, the pulse is stimulated, beats more rapidly, and the patient may become rigid or excited and give expression to emotion,—the *stage of excitement*. As this passes off the pupils contract; the pulse becomes weaker and falls below the normal; the temperature falls; the respiration is quiet, regular, sometimes stertorous; the face, which before was congested or purple, now becomes pale, there is general muscular relaxation, and the patient is ready for the operation. Complete anæsthesia usually occurs sooner under chloroform than under ether.

FIG. 4.—Esmarch chloroform inhaler and dropper.

Complications during Chloroform Anæsthesia.—1. *Vomiting,* which may occur as in the use of ether, and the same precautions and treatment are indicated.

2. *Interference with Respiration.*—Respiration may be arrested during the stage of rigidity, the jaws being tightly closed and the tongue drawn back so as to press down the epiglottis and close the larynx, while the face becomes bluish or purple. By drawing the tongue forward after prying the mouth open respiration is usually re-established. Sometimes respiration suddenly ceases from paralysis of the respiratory centre, and if not quickly restored by lowering the head, drawing the tongue forward, and resorting to artificial respiration, the heart ceases to beat and death results.

3. *Heart Failure.*—Arrest of the heart's action may be gradual or fearfully sudden. The pulse may become intermittent and the face pale; or the pulse may suddenly stop, the pupils become widely dilated, and the face deathly white. Heart failure is the greatest danger, and may occur either at the beginning or more frequently at a later stage during the administration of chloroform. It is caused by paralysis of the heart, and requires prompt treatment. Lower and extend the head by raising the foot of the table; push the lower jaw forward, draw out the tongue, and practise artificial respiration. It is well to pass the finger into the larynx, in order to detect and remove any foreign body. This may be supplemented by vigorous blows over the region of the heart, in order to stimulate its action. Electrical stimulation of the phrenic nerves may be tried, placing an electrode on each side of the neck and interrupting the current by removing one of the electrodes about every two seconds. Tracheotomy may be necessary. Artificial respiration should be kept up from half an hour to an hour, until the patient recovers or is evidently dead. Other methods or aids are the injection of strychnine, one-thirtieth of a grain; or of nitroglycerin, one-fiftieth of a minim; sprinkling the face with cold water; slapping the face or breast with a wet towel; intravenous infusion of physiological salt solution; or dilatation of the sphincter ani by introducing the fingers.

Comparison of Ether and Chloroform.—Ether is slower in action, more disagreeable to the patient, is more apt to cause vomiting, is inflammable, requires more of it to produce anæsthesia, and is more apt to be followed by renal or pulmonary inflammation. On the other hand, ether seems to be undeniably much safer than chloroform, especially for the inexperienced anæsthetizer. It is obviously impossible to get accurate statistics as to mortality, as the experience of different observers varies between such wide limits. It has been estimated that chloroform causes one death in about every twenty-five

hundred cases, while ether causes one death in about every eight thousand cases, thus being three or four times safer than chloroform; therefore ether is to be preferred in the majority of cases in civil practice, especially in prolonged operations or those likely to be accompanied by considerable shock or in which there is any heart trouble. Chloroform is quicker in action, requiring but little over half the time of ether to produce insensibility, more agreeable to the patient, less irritating to the air-passages and kidneys, requires a smaller quantity, is but slightly inflammable and is not explosive, is less likely to be followed by nausea and vomiting, is less expensive, and occupies less space proportionately in transportation. Chloroform is preferred in children under ten years of age, on account of its less irritating effect on the pulmonary mucous membrane; in old age, especially if atheroma of the arteries exists, chloroform being less likely to cause struggling or violent efforts which may cause rupture of diseased arteries; in operations on the brain or thyroid gland, as it is less likely to cause venous engorgement of these regions; in pulmonary and renal diseases; in obstetrics; in alcoholic subjects, unless there is heart disease; in emergency surgery where the operation is short and the anæsthetic has to be given soon after eating; and in military surgery where time and bulk are important elements. In tropical climates chloroform is generally preferred, and the mortality seems to be much less than in colder climates.

NITROUS OXIDE GAS.—Nitrous oxide, N_2O, or laughing gas, is a colorless gas with a slightly sweetish taste and smell, and is made by heating ammonium nitrate to a temperature of 170° C. It is used chiefly by dentists in the extraction of teeth and by surgeons for short operations requiring only one or two minutes. It is inhaled by means of a special apparatus, and produces anæsthesia in a very short time —fifty or sixty seconds—and recovery is equally as rapid, although sometimes attended with headache. Nitrous oxide is considered the safest of the general anæsthetics. Only fourteen deaths have been reported in four or five million administrations (Tillmanns).

ETHYL BROMIDE is occasionally used as a general anæsthetic, on account of its speedy action and the rapid recovery from its effects and freedom from disagreeable complications, but it is not regarded as safe, and sometimes produces tonic contraction of the muscles which is more or less persistent. It is administered like ether, but with very little air.

MIXED ANÆSTHETICS.—The A. C. E. mixture (alcohol one part, chloroform two parts, and ether three parts) possesses no particular advantages. While it is considered a little safer than chloroform, it is not as safe as ether.

A convenient and agreeable method is to give chloroform until the patient is unconscious, and then continue the anæsthesia with ether.

Nitrous Oxide and Ether.—This combination has been used in England and recently in America, the nitrous oxide being first administered to insensibility, then ether is substituted, the ether being used by the closed method or with very little air. The patient is usually ready for operation in about three minutes.

Morphine and Alcohol.—Wyeth and other surgeons have used morphine in quarter-grain doses hypodermatically every fifteen or twenty minutes until two or three doses are given, and whiskey or brandy in doses of two ounces repeated every fifteen or twenty minutes as required. Wyeth quotes Matthews as having produced satisfactory narcosis for major operations by the use of whiskey alone, giving one ounce at a dose and repeating it every ten or fifteen minutes until the patient is thoroughly unconscious. These methods may be considered when the condition of the heart contraindicates the use of ether or chloroform.

LOCAL ANÆSTHESIA.

Local anæsthesia may be produced by cold; ether, rhigolene, or ethyl-chloride spray; cocaine, or eucaine.

COLD.—A small area may be deprived of sensation by holding *ice* or a mixture of salt and ice in contact with the skin for from two to five minutes, or until the parts become white and insensitive. *Ether, rhigolene, or ethyl chloride* may be used in the form of a fine spray for the same purpose. They are especially adapted to the production of anæsthesia for aspiration, exploratory punctures, or the opening of abscesses.

HYDROCHLORATE OF COCAINE.—Cocaine is the active principle of the plant erythroxylon coca and was introduced to the profession as a local anæsthetic by Koller in 1884. A two to four per cent. solution in sterilized water may be applied to the mucosa of the eye or nose by spray or drops, or injected with a hypodermic syringe into other parts.

Method of Administration.—The parts to be operated on should be disinfected and the hypodermic syringe and needle sterilized. The needle, which should be very fine and sharp, is inserted into the substance of the skin and a fraction of a drop of the solution expelled. This produces a white wheal and in two or three seconds loss of sensation in the wheal. The needle is carried a little further and the process repeated until the entire length of the proposed incision is cocainized. A few drops of the solution are injected into the subcu-

taneous tissues at regular intervals along the parts which are to be subjected to operation. Incision is then made through the skin, and if necessary a few drops of the solution may be put into the incision before proceeding further. A good plan is to inject the cocaine into the tissues adjacent or into the trunk of the nerve supplying the part to be operated on. As a rule, not more than one-third of a grain of cocaine should be injected, but if the operation is long continued as much as a grain may be used, provided there are no symptoms of poisoning. The anæsthesia lasts about fifteen minutes.

Infiltration Anæsthesia.—This is a method devised by Schleich, of Berlin, in which a large quantity of a very weak solution of cocaine is used by injection into all the tissues which are to be subjected to operation. Anæsthesia is produced not only by the action of the drug, but also by the mechanical pressure of the fluid. Schleich uses three solutions of different strength, as follows:

No. 1.—Strong.

Cocaine muriate	.2	gramme	(gr. 3)
Morphine muriate	.025	"	(gr. $\frac{2}{5}$)
Sodium chloride	.2	"	(gr. 3)
Distilled water, sterilized, to	100.	grammes	(oz. $3\frac{2}{3}$)

No. 2.—Normal.

Cocaine muriate	.1	gramme	(gr. $1\frac{1}{2}$)
Morphine muriate	.025	"	(gr. $\frac{2}{5}$)
Sodium chloride	.2	"	(gr. 3)
Distilled water, sterilized, to	100.	grammes	(oz. $3\frac{2}{3}$)

No. 3.—Weak.

Cocaine muriate	.01	gramme	(gr. $\frac{1}{6}$)
Morphine muriate	.025	"	(gr. $\frac{2}{5}$)
Sodium chloride	.2	"	(gr. 3)
Distilled water, sterilized, to	100.	grammes	(oz. $3\frac{2}{3}$)

Two drops of 5 per cent. carbolic solution should be added in each case, to preserve the mixture.

Use of Cocaine.—Cocaine is used almost to the exclusion of general anæsthetics in operations on the eye, nose, and throat. It is often used for the opening of abscesses, the amputation of fingers or toes, circumcision, the removal of small tumors, including goiter, and even in such operations as amputation of the leg or arm, of the breast, herniotomy, and appendectomy. It may be used in operations on the urethra, but in smaller quantities than elsewhere on account of danger, as the urethra seems to absorb it more freely than other parts. Cocaine cannot be satisfactorily used in children or in nervous

persons, on account of their naturally nervous perturbation at the idea of being operated on.

Dangers of Cocaine.—Cocaine in large doses acts as a depressant upon the heart and brain, and has produced death by paralysis of the heart. It is readily absorbed, especially if in warm solution, by the mucous membranes of the urethra, eye, and nose, so that especial caution should be observed in using it on these parts. Another danger of the use of cocaine is the appetite which may be acquired for the drug, an appetite resembling that for morphine, equally as pernicious and possibly more difficult to break up.

The best antidote for cocaine poisoning is amyl nitrite by inhalation (Feinberg). Nitroglycerin may also be used.

EUCAINE.—Eucaine is a synthetic preparation, sometimes used as a substitute for cocaine. The indications for its use are the same as those for cocaine. It has certain advantages: it can be sterilized by boiling without impairment of its strength; it does not deteriorate by long standing; the anæsthesia is of longer duration; there is less danger of cardiac depression; and larger doses may be used. The *disadvantages* are its slower action and occasional sloughing of some of the tissues in which it is used.

SPINAL ANÆSTHESIA.—Injection of cocaine or eucaine into the subdural space of the spinal canal for the production of anæsthesia was first demonstrated by Leonard Corning, of New York, in 1885, but it was not practised to any extent until Bier and Tuffier in 1899 published the results of their experience. The drug is introduced as follows: A hypodermatic syringe, with a gold or platinum needle about four inches long, is required. All aseptic precautions must be carefully observed. The patient is placed in a sitting position and made to stoop over so as to render the vertebræ prominent. A line is drawn across the back between the highest points of the iliac crests. The spinous process of the fourth lumbar vertebra is found just above this line, and the needle is inserted about one-fifth of an inch to the right of the spinous process and directed forward, upward, and inward for about two and one-half to three and one-half inches (depending on the size and thickness of the parts), or until the cerebrospinal fluid can be drawn into the syringe. The syringe is then detached and the finger held on the needle to prevent the escape of cerebrospinal fluid until another syringe containing the solution of sterilized cocaine can be attached to the needle. Ten or fifteen minims of a two per cent. solution are injected. The needle should be kept in place until anæsthesia appears, as it may be necessary to repeat the injection. Anæsthesia of all the parts below the diaphragm is usually complete in from five to fifteen minutes, and lasts from forty-five minutes to an

hour, sometimes longer. Anæsthesia is so complete that any operation on the parts below the diaphragm not requiring longer than thirty or forty-five minutes can be performed without pain. Amputation of the thigh, hysterectomy, and operations on all the abdominal viscera, including the intestines, kidneys, and liver, have been satisfactorily performed.

After Effects.—Nausea, headache, and insomnia occur in most cases; and sometimes vomiting, chill, fever, involuntary defecation and urination, and retention of urine. Fatal results have occurred.

COCAINE WITH THE GALVANIC CURRENT.—The unbroken skin may be cocainized by dipping the anode of a galvanic battery in cocaine solution, placing it upon the skin a short distance from the cathode, then turning on a current of the strength of from two to four milliamperes. Cataphoresis takes place, moving the fluids from the anode to the cathode, and the portion of skin between the electrodes becomes anæsthetized.

CHAPTER VI.

LIGATION OF ARTERIES.

THE ligation of arteries in continuity may be required for the arrest of hemorrhage when the bleeding points are inaccessible, for starving tumors and other growths, or for the cure of aneurism. The best materials for this purpose are kangaroo tendon, catgut, or other absorbable animal tissue, and sometimes silk.

The instruments needed are the following:

A sharp scalpel,
An Allis's blunt dissector,
A tenaculum,
A pair of straight scissors,
A pair of curved-on-the-flat scissors,
Six pairs of hæmostatic forceps,
A pair of suitable retractors,
An aneurism-needle or ligature-carrier,
Needles and needle-holder,
Two pairs of dissecting forceps with fine teeth.

GENERAL METHOD OF OPERATING.—Strict aseptic precautions must be observed. The general course of the artery is located by certain landmarks. The surgeon, holding the knife as a pen or as a violin-bow between the thumb and first two fingers of his right hand, makes an incision from two to four inches in length parallel with and over the portion of the artery which is to be ligated. If the artery is superficial, after division of the skin the fascia should be carefully divided on a grooved director. When the vessel lies deeply, the surgeon divides skin and fascia at one stroke, and seeks the vessel through the nearest intermuscular space, dissecting the muscles apart by Allis's blunt dissector. Having found the vessel, the sheath is opened by picking up a portion with the rat-tooth forceps and cutting it with the point of the knife held obliquely. Through this opening a grooved director is inserted, and the sheath split up for about half an inch, or far enough to permit the use of the aneurism-needle in applying the ligature. The aneurism-needle, threaded with the ligature, is carefully introduced between artery and vein, with its point towards the artery and away from the vein, in order to avoid wounding the vein or nerve or including them in the ligature. The loop of the ligature is caught by a tenaculum or forceps, and one end pulled through on one side of the artery, while the aneurism-needle is with-

drawn along the other end. The ligature is tied, if animal tissue, by the "surgeon's knot," to avoid slipping. The ligature should be applied tight enough to occlude the lumen of the vessel, but not tight enough to cut through its coats. The ends are cut short, all hemorrhage is arrested, and the wound closed without drainage by sutures through the skin and fascia. A fact worth remembering is that every artery of much size below the axilla and below the tendinous arch of the soleus muscle is accompanied by two veins (venæ comites), one on either side.

LIGATION OF THE INNOMINATE ARTERY.—The innominate artery lies behind the upper part of the sternum and the right sternoclavicular articulation, and is about one inch and a half in length from its origin at the aorta to its division into the subclavian and common carotid.

Relations.—In front are the sternohyoid and sternothyroid muscles and the left innominate and right inferior thyroid veins. Behind are the trachea and pleura. To the outer side are the right innominate vein, the right pneumogastric nerve, and the pleura, and to the inner side are the left inferior thyroid vein and the trachea.

Operation.—The patient should have a hard pillow under the shoulders so that the head may be thrown back. Make an incision about three inches long along the anterior edge of the sternocleidomastoid muscle to the sternoclavicular articulation. Join this by another incision of the same length along the clavicle. If the anterior and external jugular veins are in the way, ligate and divide them. Divide the sternal and a part of the clavicular attachment of the sternocleidomastoid, exposing the sternohyoid and sternothyroid muscles covered by the thyroid veins. Press the veins to one side, or ligate and divide them, and separate the attachments of the sternohyoid and sternothyroid muscles. Divide the deep fascia and expose the bifurcation of the artery. Separate the structures gently from the artery until the aneurism-needle can be passed below the point of bifurcation. The ligature should be passed from without towards the inner side, in order to avoid the right innominate vein, pneumogastric nerve, and pleura, and should be tied as far below the point of bifurcation as possible.

Milton's method of exposing the anterior mediastinum may be modified for ligation of this vessel, as follows:[1] "1. A median incision is made from the larynx to the middle of the sternum or lower, dividing the skin and deep fascia above and the periosteum also below. 2. The sternohyoid and sternothyroid muscles are followed down to their sternal insertion, retractors being placed so as to draw the soft

[1] B. F. Curtis, Annals of Surgery, October, 1901.

parts at the base of the neck widely apart. 3. A transverse incision is made through the periosteum along the upper border of the manubrium and the periosteum and muscles are detached from the

FIG. 5.—Milton's method of exposing the anterior mediastinum.

posterior surface of the bone by blunt elevators and the finger, as far as can be reached. 4. The ordinary amputation saw is then applied to the bone in the line of the vertical incision in the periosteum, the soft parts in the neck and behind the sternum being protected by flat metal strips. The saw is held with its point turned towards the neck and the handle towards the ensiform cartilage. It should cut most deeply above and entirely divide the manubrium at its upper border, the cut being more shallow below and only grooving the bone at its lower end. This obliquity of the cut necessitates the long skin incision which has been described. 5. A stout chisel is then applied in the saw-cut at the superior border of the manubrium and the thin layer of undivided bone on the posterior surface is made to give way as the wedge action of the chisel forces the two halves apart. 6. The skin being well retracted, a transverse incision is made in the periosteum across the face of the bone at the level of the first or second intercostal space, and the chisel is applied in this line, directed obliquely outward from the middle line on each side, so as to divide each half of the bone from the body of the sternum. The instrument must not be allowed to cut entirely through the bone at the outer border for fear of injury to the pleura or internal mammary artery. Both

lie a little distance from the bone, so that the danger of wounding them is not great. 7. Strong retractors are then inserted in the median saw-cut, and with a little force the two halves can be sufficiently separated to allow access to the periosteum, which should be carefully incised or scratched through with the point of the knife, beginning above where the danger of damage to the subjacent parts is least. As the periosteum is divided the halves of the bone can be more widely separated, and this interval gradually extends from an inch to nearly twice that distance as the steady, strong traction is maintained during the subsequent operation. A separation of three centimetres can be obtained in any case and this is abundant. The smaller intercostal branches of the internal mammary artery are somewhat tortuous and sufficiently long to allow free motion of the bone without receiving injury. The appearance of the floor of the wound is shown in the sketch from the cadaver, opposite. 8. The muscles and fascia are then divided by blunt dissection or with forceps and scissors in the median line, beginning above, double ligatures being applied to the veins which cross the line of incision. The trachea and great vessels at the root of the neck can be freely exposed. After the ligation the two halves of bone are united with sutures and the wound is closed without drainage, except at the lower angle, where drainage may be necessary, unless hæmostatis has been complete."

Very few successful ligations of the innominate artery have been performed, the cases usually dying from secondary hemorrhage, shock, or sepsis.

LIGATION OF THE SUBCLAVIAN ARTERY.—The subclavian artery arises from the innominate on the right, and the arch of the aorta on the left side, and extends to the lower border of the first rib, being covered in the *second* part of its course by the scalenus anticus muscle, the portion to the inner side of this muscle being called the *first* portion and that to the outer side the *third* portion. The third portion is that of election for ligation. The artery may be ligated in its first portion by an incision similar to that made for ligating the innominate; the second and third portions may be ligated through the same incision.

Operation.—The shoulders should be elevated by a hard pillow, the head thrown back and turned towards the opposite side, and the shoulder on the side to be ligated drawn downward. Draw the skin downward over the clavicle, and make an incision down to the bone, four or five inches in length, from an inch external to the sterno-clavicular articulation outward. On relaxing pressure the incision rises just above the clavicle, the external jugular vein is drawn to one

side, or ligated and divided. It sometimes crosses the clavicle, and in that case would be divided by the first incision. Divide the deep fascia upon a grooved director, and draw the posterior belly of the omohyoid muscle upward and outward. Separate the loose areolar

FIG. 6.—Anatomical relations in the cervical region.

tissue and deep fascia, and draw the suprascapular artery and vein and transverse cervical veins out of the way; feel for the outer border of the scalenus anticus muscle, and trace it down to its insertion into the tubercle of the first rib. The artery lies to the outer side and behind the tubercle, while the vein lies in front and to its inner side. The artery is recognized by its position and pulsation. The cords of the brachial plexus of nerves lie above and to the outer side of the artery, while the pleura lies behind and below the second portion of the vessel. The aneurism-needle containing the ligature should be passed from below upward and from before backward, taking care not to include a cord of the brachial plexus or the phrenic nerve, which usually lies on the anterior surface of the scalenus anticus muscle. In ligating the first portion of the subclavian on the left side, the internal jugular and left innominate veins and the thoracic duct must be avoided, the internal jugular vein being to the outer side, the innominate veins in front, and the thoracic duct to the inner side.

LIGATION OF THE COMMON CAROTID ARTERY.—The common carotid arteries are alike on the two sides, after entering the neck, from the sternoclavicular articulation onward, but on the left side the artery arises from the aorta, and is, therefore, longer and deeper than the right carotid. The artery extends from the sternoclavicular

articulation to its bifurcation into the internal and external carotids at the upper border of the thyroid cartilage. The vessel is crossed about the middle of its course opposite the cricoid cartilage by the omohyoid muscle, and it is just above this point, in the "triangle of election," that the artery is ligated by preference.

Relations.—In front (superficial) are the skin, fascia, platysma, sternomastoid, and omohyoid muscles, the descendens noni nerve, and the anterior jugular and thyroid veins. Behind are the inferior thyroid artery, recurrent laryngeal nerve, and sympathetic nerve. To the inner side are the trachea, thyroid gland, recurrent laryngeal nerve, and inferior thyroid artery. Externally are the internal jugular vein and pneumogastric nerve. The artery, vein, and nerve are contained in one sheath, the nerve being between and behind the vessels.

Operation.—Place a pillow under the patient's shoulders, extend the neck, and turn the face towards the opposite side. A line drawn from a point midway between the angle of the jaw and the mastoid process to the sternoclavicular articulation represents the course of the vessel. Make an incision about three inches long along the anterior border of the sternocleidomastoid muscle, with its centre opposite the cricoid cartilage. Divide the skin, fascia, and platysma, exposing the anterior edge of the sternomastoid, which is retracted outward, while the sternohyoid and sternothyroid muscles are retracted inward. The artery is found in this muscular interspace crossed by the omohyoid muscle. The sheath, upon which is seen the descendens noni nerve, is opened, and the ligature passed from without inward, to avoid the internal jugular vein and pneumogastric nerve. The internal jugular vein can be ligated by the same incision, an operation which is sometimes necessary in thrombosis of that vessel and of the lateral sinus.

Ligation of the External Carotid Artery.—This vessel extends from the upper border of the thyroid cartilage to the neck of the condyle of the lower jaw, behind which it divides into the temporal and internal maxillary branches. Its principal relations are as follows: In front, the hypoglossal nerve, lingual and facial veins, and the parotid gland with the facial nerve and temporomaxillary vein in its substance. Behind are the superior laryngeal and glossopharyngeal nerves. Externally and behind is the internal carotid artery. This artery gives off eight branches.

Operation.—Place the patient in the same position as for ligation of the common carotid, make an incision over the anterior border of the sternomastoid muscle and from the angle of the jaw to a point opposite the middle of the thyroid cartilage. On dividing the skin

LIGATION OF THE SUPERIOR THYROID ARTERY.—This artery, the first branch of the external carotid, arises something less than an inch below the greater cornu of the hyoid bone and passes slightly upward and inward before turning downward to enter the thyroid gland.

Operation.—Make an incision about three inches long over the anterior border of the sternocleidomastoid with its centre slightly below the cornu of the hyoid bone (about the same incision as that for ligation of the external carotid). Expose the external carotid at its origin and identify the thyroid by its being the first branch given off and its position just below the cornu of the hyoid bone. Pass the ligature from above downward.

LIGATION OF THE LINGUAL ARTERY.—This is the second branch given off from the anterior portion of the external carotid, and arises almost opposite, but slightly below, the greater cornu of the hyoid bone, and may be ligated by the incision for ligating the external carotid, or it may be ligated in Lesser's triangle by a curved incision from near the angle of the jaw just in front of the facial artery downward and forward to the greater cornu of the hyoid bone, then forward and upward towards the chin. The skin and fascia being divided, the submaxillary gland is exposed and retracted upward. Lesser's triangle is now seen, the base, which is upward, being formed by the hypoglossal nerve, while the two sides are formed by the anterior and posterior bellies of the digastric muscle. The hyoglossus muscle forms the floor of the triangle. On separating the fibres of this muscle the lingual artery is found beneath near the hyoid bone. The ligature is passed around the vessel from above downward.

LIGATION OF THE FACIAL ARTERY.—The facial is the third of the anterior branches of the external carotid; arising a short distance above the lingual, it passes upward and forward beneath the body of the inferior maxilla, crossing that bone through a groove about an inch in front of the angle, and then runs forward and upward to the angle of the mouth and side of the nose.

Operation.—In common with the superior thyroid and lingual it may be ligated through the incision for ligation of the external carotid, but it is most easily reached where it crosses the inferior maxilla just in front of the masseter muscle by an incision about one inch in length along the lower border of that bone. The skin, fascia, and platysma having been divided, the vessel is exposed and should be separated from its vein in passing the ligature.

LIGATION OF THE TEMPORAL ARTERY.—One of the terminal branches of the external carotid, this vessel passes from its origin

behind the neck of the condyle of the lower jaw through the parotid gland, across the zygoma, and about two inches above that process divides into its terminal branches. The vessel is ligated by an incision one inch in length, about one-quarter of an inch in front of the tragus of the ear. The artery is found beneath the skin and deep fascia accompanied by its vein, and the ligature is passed from behind forward.

Ligation of the Occipital Artery.—From its origin from the external carotid a little above the facial, the occipital artery passes backward and upward beneath the parotid gland and digastric and stylohyoid muscles through the occipital groove of the mastoid process. The artery may be ligated at its origin or behind the mastoid process.

Operation.—At its Origin.—Make an incision over the anterior border of the sternomastoid, with the centre of the incision opposite the greater cornu of the hyoid bone (the same as the incision for ligating the external or internal carotid). Divide the skin and fascia carefully until the posterior belly of the digastric muscle is exposed, and just below will be seen the hypoglossal nerve winding from behind forward around the occipital artery. *Behind the Mastoid Process.*—Make a horizontal incision about two inches in length from just below the mastoid process backward and inward. Divide the skin and part of the attachments of the sternomastoid and splenius muscles. The artery is found at the bottom of the wound just after its passage through the occipital groove.

Ligation of the Inferior Thyroid Artery.—Arising from the thyroid axis, the inferior thyroid artery passes upward and inward behind the carotid sheath, to enter the thyroid gland opposite the fifth cervical vertebra. In front of the vessel are the common carotid artery, the internal jugular vein, and the pneumogastric nerve and sympathetic nerve with the middle cervical ganglion.

Operation.—Make an incision as if to ligate the common carotid below the omohyoid muscle. Expose the sheath of the carotid artery and draw it outward with the sternomastoid muscle. The inferior thyroid is found behind the sheath opposite the fifth cervical vertebra. In passing the ligature avoid the recurrent laryngeal nerve which is behind, and the thoracic duct if low down on the left side.

Ligation of the Vertebral Artery.—The vertebral artery, arising from the first portion of the subclavian, passes upward, enters the foramen in the transverse process of the sixth cervical vertebra and through the corresponding foramina of the vertebræ above. After passing through the atlas it turns backward around its articular process and enters the skull through the foramen magnum. In

front of the vessel are the carotid sheath and its contents, the inferior thyroid artery, and the vertebral vein.

Operation.—The vessel is usually tied in its first portion before entering the foramen of the sixth cervical vertebra. Make an incision about four inches long over the anterior border of the sternomastoid muscle upward from the sternoclavicular articulation. The sternomastoid muscle is drawn outward and the carotid sheath and contents either outward or inward as may be most convenient. The deep fascia is separated by blunt dissection, and the interval between the scalenus anticus and longus colli muscles is sought about an inch below the tubercle of the sixth cervical vertebra. Here the artery is seen covered by its vein. The ligature should be passed from without inward and from behind forward. The vessel may be ligated by an incision along the posterior border of the sternocleidomastoid muscle.

LIGATION OF THE INTERNAL MAMMARY ARTERY.—The internal mammary artery arises from the first part of the subclavian and passes downward along the posterior surface of the costal cartilages about half an inch from their junction with the sternum to the sixth intercostal space, where it divides.

Operation.—The artery may be ligated in any one of the first five intercostal spaces by an incision, vertical or horizontal, exposing the artery about half an inch from the border of the sternum. In passing the ligature look out for the pleura, especially in the first two intercostal spaces.

LIGATION OF THE AXILLARY ARTERY.—This vessel is the continuation of the subclavian artery and extends from the lower border of the first rib to the lower border of the tendon of the latissimus dorsi. The artery is divided into three portions by the pectoralis minor which crosses its middle. In front are the pectoralis major (and over its *second* portion the pectoralis minor), the external anterior thoracic nerve, and the cephalic and acromiothoracic veins. To its outer side is the brachial plexus and to its inner side the axillary vein. The *third* portion of the artery is embraced by the roots of the median nerve, and has on its outer side the median and musculocutaneous nerves, and to its inner side the ulnar and internal cutaneous nerves. The artery is usually ligated in its first or third portions.

Operation.—First Portion.—The shoulder should be elevated as much as possible to give room below the clavicle. Make an incision three or four inches in length from half an inch from the sternoclavicular articulation downward and outward in the space between the pectoralis major and deltoid muscles. Separate the deltoid and

along the inner border of the coracobrachialis muscle, and in the middle and lower thirds along the inner border of the biceps. Remember that the median nerve crosses the artery about the middle from the outer to the inner side. It is accompanied by venæ comites, and has to its inner side the basilic vein and the ulnar and internal cutaneous nerves. The brachial is usually ligated at the middle of the arm or at the bend of the elbow.

Operation.—At the Middle of the Arm.—Make an incision about three inches long in the line of the artery along the inner border of the biceps muscle through the skin and superficial fascia, avoiding the basilic vein, which is slightly to the inner side. The biceps is drawn outward, exposing the sheath which encloses the artery and venæ comites. The median nerve, which is in front of or to the inner or outer side of the artery, is drawn inward or outward as may be convenient, the sheath opened, and the ligature passed around the vessel, taking care not to include the venæ comites. Occasionally two arteries are found, on account of high division of the brachial. *At the Bend of the Elbow.*—With the forearm supinated make an incision about two inches in length along the inner border of the biceps tendon, avoiding as far as possible the superficial veins and the internal cutaneous nerve. Divide the bicipital aponeurosis. The artery is found between the biceps tendon and the median nerve.

LIGATION OF THE RADIAL ARTERY.—The radial artery extends from the middle of the front of the elbow along the radial side of the

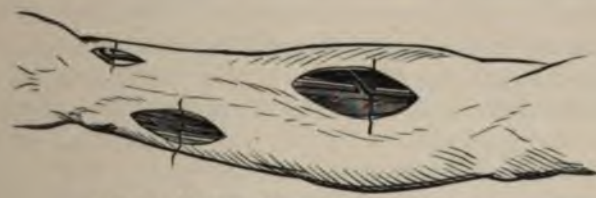


FIG. 10.—Ligation of radial and ulnar arteries.

forearm to the carpus, around which it winds backward, beneath the extensor tendons of the thumb, and enters the palm of the hand between the first two metacarpal bones, then crosses the bases of the metacarpal bones to the ulnar side of the hand, where it inosculates with the deep branch of the ulnar artery, forming the deep palmar arch. The artery may be ligated in any part of its course,—the upper, middle, or lower third of the forearm, or in the palm of the hand.

Operation.—In the Upper Third.—The course of the radial artery is indicated by a line drawn from a point half an inch below the middle of the front of the elbow-joint to the ulnar side of the styloid

side, or ligated and divided. It sometimes crosses the clavicle, and in that case would be divided by the first incision. Divide the deep fascia upon a grooved director, and draw the posterior belly of the omohyoid muscle upward and outward. Separate the loose areolar

FIG. 6.—Anatomical relations in the cervical region.

tissue and deep fascia, and draw the suprascapular artery and vein and transverse cervical veins out of the way; feel for the outer border of the scalenus anticus muscle, and trace it down to its insertion into the tubercle of the first rib. The artery lies to the outer side and behind the tubercle, while the vein lies in front and to its inner side. The artery is recognized by its position and pulsation. The cords of the brachial plexus of nerves lie above and to the outer side of the artery, while the pleura lies behind and below the second portion of the vessel. The aneurism-needle containing the ligature should be passed from below upward and from before backward, taking care not to include a cord of the brachial plexus or the phrenic nerve, which usually lies on the anterior surface of the scalenus anticus muscle. In ligating the first portion of the subclavian on the left side, the internal jugular and left innominate veins and the thoracic duct must be avoided, the internal jugular vein being to the outer side, the innominate veins in front, and the thoracic duct to the inner side.

LIGATION OF THE COMMON CAROTID ARTERY.—The common carotid arteries are alike on the two sides, after entering the neck, from the sternoclavicular articulation onward, but on the left side the artery arises from the aorta, and is, therefore, longer and deeper than the right carotid. The artery extends from the sternoclavicular

LIGATION OF THE SUPERFICIAL PALMAR ARCH.—This arch is the continuation of the ulnar artery outward across the palm to the radial side, where it inosculates with a branch from the radial artery. It is covered by the skin, palmaris brevis muscle, and palmar fascia, and is indicated by a line drawn across the palm in line with the thumb when set at right angles to the hand.

Operation.—The arch is exposed by an incision across its course through the skin and palmar fascia in line with the fingers.

LIGATION OF THE INTERCOSTAL ARTERIES.—The intercostal arteries, except the first, which arises from the subclavian, come from the aorta, and are eleven in number on each side. They pass outward to the intercostal space, where each artery divides into two branches, an anterior and a posterior. The anterior branch divides near the angle of the rib into two branches, the larger running in the groove in the lower border of the rib above, while the smaller runs along the upper border of the rib below.

Operation.—An intercostal artery may be ligated through an incision parallel with and over the rib beneath which the vessel runs. The soft parts, including the artery, may be separated from the rib by a periosteal elevator, or, if necessary, a portion of the rib may be excised.

LIGATION OF THE ABDOMINAL AORTA.—Make an incision through the left rectus muscle, about four inches in length, with its centre opposite the umbilicus. Open the peritoneal cavity; press the intestines to the right; locate the aorta by its pulsation; tear through the peritoneum covering it, in order to prevent hemorrhage, being careful not to injure the vena cava and the sympathetic nerve, and pass the ligature from right to left.

Of 14 ligations of the aorta, 12 for aneurism and 2 for traumatism, all have been fatal.

LIGATION OF THE COMMON ILIAC ARTERY.—Each common iliac artery extends from its origin at the bifurcation of the aorta at the left side of the body of the fourth lumbar vertebra to the upper border of the sacro-iliac synchondrosis, being about two inches in length, the right being slightly longer than the left. The right artery crosses both the left and right iliac veins, while the left artery lies to the outer side of the left vein. The ureters cross the arteries about or just after their bifurcation into the internal and external iliac; the right artery has in front of it the ileum, while the left has in front the superior hemorrhoidal artery and the rectum. The linear guide to the vessels is a line drawn from a point a little below and to the left side of the umbilicus to a point midway between the symphysis pubis and the anterior superior spinous process.

and fascia the external jugular and temporofacial veins are exposed, and should be drawn out of the way, or ligated and divided. This exposes the artery crossed by the hypoglossal nerve and the sterno-

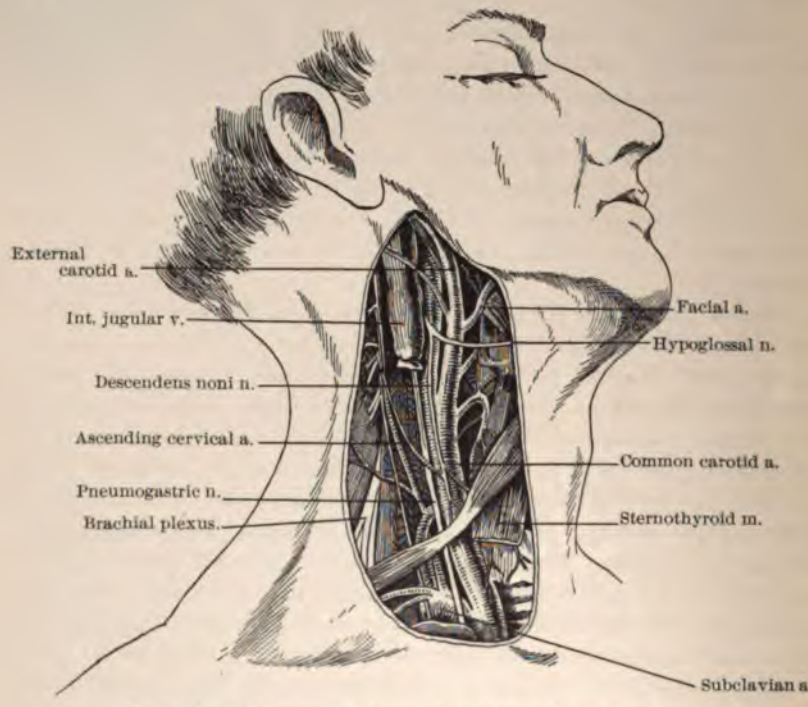


FIG. 7.—Surgical anatomy of the arteries of the neck. (After Gray.)

hyoid and digastric muscles. The artery is identified by finding some of its branches. The needle is passed from without inward, or from behind forward, carefully avoiding the internal jugular vein and the pneumogastric nerve.

LIGATION OF THE INTERNAL CAROTID ARTERY.—The internal carotid passes upward from the level of the superior border of the thyroid cartilage and enters the skull through the carotid foramen. In the neck it lies at the front of the transverse processes of the first three cervical vertebræ.

Operation.—The incision is the same as that for ligating the external carotid, and the relations of the vessel at the point of ligation near its origin are nearly the same, it being posterior and a little external to the external carotid. The ligature is passed from without inward.

The Transperitoneal Method.—Make an incision near the outer border of the rectus muscle, or open the abdominal cavity by the "gridiron" method for appendectomy.

The Extraperitoneal Method.—Make a curved incision from a point an inch above the middle of Poupart's ligament, upward and outward to a point on a level with, but two inches internal to, the anterior spine of the ilium. Divide the skin, fascia, and muscles until the peritoneum is exposed. This is stripped upward and inward until the outer border of the psoas muscle is recognized, when the vessel can be felt pulsating along the inner border of this muscle. Pass the ligature from within outward. The *deep epigastric* and *deep circumflex iliac* arteries may be ligated by means of this incision.

FIG. 11.—Ligation of external iliac and femoral arteries.

FIG. 12.—Ligation of femoral artery at the apex of Scarpa's triangle.

LIGATION OF THE GLUTEAL ARTERY.—The gluteal artery is the continuation of the posterior trunk of the internal iliac and passes out of the pelvis through the great sacrosciatic foramen above the pyriformis muscle.

Operation.—With the patient on his abdomen or side and the thigh rotated inward, make an incision four or five inches in length from the posterior spinous process of the ilium towards the trochanter major in line with the fibres of the gluteus maximus muscle. Separate the fibres of this muscle, and the artery will be found beneath, at the upper border of the pyriformis, just after its escape from the great sacrosciatic notch.

LIGATION OF THE SCIATIC ARTERY.—The sciatic artery, one of the terminal branches of the anterior trunk of the internal iliac,

behind the neck of the condyle of the lower jaw through the parotid gland, across the zygoma, and about two inches above that process divides into its terminal branches. The vessel is ligated by an incision one inch in length, about one-quarter of an inch in front of the tragus of the ear. The artery is found beneath the skin and deep fascia accompanied by its vein, and the ligature is passed from behind forward.

LIGATION OF THE OCCIPITAL ARTERY.—From its origin from the external carotid a little above the facial, the occipital artery passes backward and upward beneath the parotid gland and digastric and stylohyoid muscles through the occipital groove of the mastoid process. The artery may be ligated at its origin or behind the mastoid process.

Operation.—At its Origin.—Make an incision over the anterior border of the sternomastoid, with the centre of the incision opposite the greater cornu of the hyoid bone (the same as the incision for ligating the external or internal carotid). Divide the skin and fascia carefully until the posterior belly of the digastric muscle is exposed, and just below will be seen the hypoglossal nerve winding from behind forward around the occipital artery. *Behind the Mastoid Process.*—Make a horizontal incision about two inches in length from just below the mastoid process backward and inward. Divide the skin and part of the attachments of the sternomastoid and splenius muscles. The artery is found at the bottom of the wound just after its passage through the occipital groove.

LIGATION OF THE INFERIOR THYROID ARTERY.—Arising from the thyroid axis, the inferior thyroid artery passes upward and inward behind the carotid sheath, to enter the thyroid gland opposite the fifth cervical vertebra. In front of the vessel are the common carotid artery, the internal jugular vein, and the pneumogastric nerve and sympathetic nerve with the middle cervical ganglion.

Operation.—Make an incision as if to ligate the common carotid below the omohyoid muscle. Expose the sheath of the carotid artery and draw it outward with the sternomastoid muscle. The inferior thyroid is found behind the sheath opposite the fifth cervical vertebra. In passing the ligature avoid the recurrent laryngeal nerve which is behind, and the thoracic duct if low down on the left side.

LIGATION OF THE VERTEBRAL ARTERY.—The vertebral artery, arising from the first portion of the subclavian, passes upward, enters the foramen in the transverse process of the sixth cervical vertebra and through the corresponding foramina of the vertebræ above. After passing through the atlas it turns backward around its articular process and enters the skull through the foramen magnum. In

The trunk of the common femoral artery is only an inch and a half or two inches in length before it divides into the superficial femoral and the profunda. Open the sheath of the vessels carefully and pass the ligature from within outward.

At the Apex of Scarpa's Triangle.—This is the point of election. The *base* of Scarpa's triangle is formed by Poupart's ligament, its *inner* side by the adductor longus, and its *outer* side by the sartorius muscle. The femoral artery passes through the middle of the triangle from base to apex. It has in *front* the skin, fascia, and internal cutaneous nerve; *behind*, the femoral vein, the profunda artery and vein, and muscles; to the *outer* side, the anterior crural and long saphenous nerves; and to the *inner* side, the femoral vein before becoming posterior. *Operation.*—With the thigh flexed and rotated outward, make an incision in the line of the artery, three inches in length, beginning three inches below Poupart's ligament. On dividing the skin and fascia the edge of the sartorius muscle will be exposed, and on drawing it to the outer side the sheath of the vessels is seen. Open the sheath and pass the ligature from within outward. (See Fig. 12.)

In Hunter's Canal.—This is a space occupying the middle third of the thigh, extending from the apex of Scarpa's triangle to the opening in the adductor magnus muscle. It is formed by an aponeurosis extending from the vastus internus on the outer side to the adductor longus and magnus muscles on the inner side. The femoral artery and vein, enclosed in a sheath, pass beneath this aponeurosis with the internal saphenous nerve, the vein being behind and to the outer side of the artery. *Operation.*—With the thigh flexed and rotated outward, make an incision four inches in length in the line of the artery from the junction of the upper and middle third of the thigh downward, being careful to avoid the internal saphenous vein. On dividing the skin and fascia, the sartorius muscle comes into view and should be drawn to the inner or outer side. This exposes the roof of Hunter's canal, which is cautiously opened, when the saphenous nerve is seen lying on the sheath of the vessels or to its outer side. Open the sheath and pass the ligature from without inward, avoiding both nerve and vein.

Anomalies.—Sometimes two femoral arteries are found in Hunter's canal, which unite before passing through the opening in the adductor magnus muscle. Occasionally the femoral artery is continuous with the internal iliac and runs down the back of the thigh with the great sciatic nerve. There are anomalies also as to number and position of the femoral vein.

LIGATION OF THE POPLITEAL ARTERY.—The popliteal artery

extends from the opening in the adductor magnus to the lower border of the popliteus muscle, where it divides into the tibial arteries. The artery rests on the lower part of the femur, the posterior ligament of the knee-joint, and the popliteus muscle covering the upper part of the tibia. Superficial to or behind the artery are the popliteal vein and internal popliteal nerve, the latter crossing the artery from without inward. The popliteal artery gives off eight branches to the joint and muscles.

FIG. 13.—Ligation of the popliteal artery.

Operation.—The artery is most accessible in its first portion. With the patient lying on his face or side, make an incision four inches in length along the middle of the popliteal space to the knee-joint. Divide the skin and fascia until the outer border of the semimembranosus muscle is exposed. On drawing this inward and separating the areolar tissue, the nerve is seen crossing from without inward, and just beneath, covering the artery, the popliteal vein. The nerve and vein should be drawn to the outer side and the ligature passed from without inward.

LIGATION OF THE POSTERIOR TIBIAL ARTERY.—The posterior tibial extends from the bifurcation of the popliteal artery down the tibial side of the back of the leg, lying on the tibialis posticus and flexor longus digitorum muscles to the space between the internal malleolus and tuberosity of the os calcis, where it divides into the internal and external plantar arteries. It is accompanied by venæ comites and the posterior tibial nerve, which crosses its first portion

FIG. 14.—Ligation of the posterior tibial artery.

from within outward and then lies to its outer side. The artery may be ligated in its upper or middle third, or behind the internal

malleolus. The course of the vessel is indicated by a line drawn from the middle of the popliteal space to a point midway between the internal malleolus and the tuberosity of the os calcis.

Operation.—In the Upper Third.—With the patient on his back and with the leg flexed on the thigh, make an incision three or four inches in length, three-quarters of an inch (or a finger's breadth) behind the internal border of the tibia, beginning two inches below the head of the bone. Divide the skin and fascia, avoiding the internal saphenous vein, detach the tibial origin of the soleus muscle, and retract it backward and outward. Divide the fascia thus exposed and search for the artery towards the middle of the leg on the tibialis posticus muscle. Separate it from the veins and nerve and pass the ligature from without inward.

In the Middle Third.—With the patient in the same position, make an incision three inches in length, three-quarters of an inch behind the internal border of the tibia, in the middle third of the leg. Divide the skin and fascia until the inner border of the soleus muscle is found. Retract this outward and find the space between it and the flexor longus digitorum, in which the artery with its two veins and nerve to the outer side will be found.

Behind the Internal Malleolus.—Here the artery has its two veins, one in front and one behind, with the posterior tibial nerve next behind and still further behind the flexor longus hallucis. Anteriorly are the tendons of the flexor longus digitorum and tibialis posticus. Make an incision two inches in length midway between the tendo Achillis and the internal malleolus. Divide the skin, deep fascia, and internal annular ligament carefully, when the artery will be exposed.

LIGATION OF THE PLANTAR ARCH.—The plantar arch is formed by the external plantar artery, which extends from its origin at the bifurcation of the posterior tibial forward and outward in the sole of the foot to the base of the fifth metatarsal bone, then obliquely inward to the interval between the bases of the first and second metatarsal bones, where it anastomoses with the communicating branch from the dorsalis pedis. The arch may be ligated by an incision along the outer border of the sole of the foot, or by a dorsal incision with resection of a portion of the second, third, or fourth metatarsal bone (De Lorme).

LIGATION OF THE PERONEAL ARTERY.—This artery, a branch of the posterior tibial, extends from that vessel about an inch below the lower border of the popliteus muscle obliquely outward to the fibula, then downward along the inner border of the fibula to the lower third of the leg. It has in front the tibialis posticus

process of the radius. The supinator longus muscle lies to the outer side of the artery as far as the wrist. Make an incision about two and a half inches in length in the line of the artery, beginning about an inch and a half below the bend of the elbow. Divide the skin, superficial and deep fascia, and expose the edge of the supinator longus muscle, which is drawn outward, while the pronator radii teres is drawn inward, the artery lying between them, with the radial nerve some distance to the outer side, often too far away to be seen. *In the Lower Third.*—Make an incision in the line of the vessel about an inch above the wrist, using the supinator longus as a guide. The artery is found between the supinator longus and the flexor carpi radialis. It is accompanied by its veins, but the radial nerve is no longer near.

Ligation of the Deep Palmar Arch.—This may be required on account of hemorrhage from a wound of the vessel, in which case the wound would be a guide to the operation. The deep palmar arch is covered by the flexor tendons of the fingers and the flexor brevis pollicis. It lies upon the interosseous muscles and bases of the metacarpal bones. Its course is roughly indicated by a line drawn across the palm half an inch above the line of the thumb when extended at right angles to the hand. The parts should be made bloodless by an Esmarch bandage, and a longitudinal incision made in the palm of the hand across the course of the artery, dividing the skin, fat, and palmar fascia, pulling aside the flexor tendons and lumbricales muscles, and taking care not to injure the branches of the median and ulnar nerves.

Ligation of the Ulnar Artery.—From its origin the ulnar artery passes beneath the superficial layer of the flexor muscles of the forearm to the outer border of the flexor carpi ulnaris, and keeps this relation until it reaches the wrist, where it divides into two branches just beyond the radial side of the pisiform bone. The median nerve crosses the first part of the artery from its inner to its outer side, while the ulnar nerve lies in close relation to the inner side of the artery along its lower two-thirds. The artery may be ligated in the upper, middle, or lower third, or in the palm of the hand.

Operation.—The course of the vessel is indicated by a line drawn from a point half an inch below the middle of the front of the elbow-joint to the radial side of the pisiform bone. The artery may be exposed at any place along this line by an incision from two to four inches in length, using the flexor carpi ulnaris muscle as the muscular guide. In the upper third the artery is found deeply situated in the interspace between the flexor carpi ulnaris and the flexor sublimis digitorum.

LIGATION OF THE SUPERFICIAL PALMAR ARCH.—This arch is the continuation of the ulnar artery outward across the palm to the radial side, where it inosculates with a branch from the radial artery. It is covered by the skin, palmaris brevis muscle, and palmar fascia, and is indicated by a line drawn across the palm in line with the thumb when set at right angles to the hand.

Operation.—The arch is exposed by an incision across its course through the skin and palmar fascia in line with the fingers.

LIGATION OF THE INTERCOSTAL ARTERIES.—The intercostal arteries, except the first, which arises from the subclavian, come from the aorta, and are eleven in number on each side. They pass outward to the intercostal space, where each artery divides into two branches, an anterior and a posterior. The anterior branch divides near the angle of the rib into two branches, the larger running in the groove in the lower border of the rib above, while the smaller runs along the upper border of the rib below.

Operation.—An intercostal artery may be ligated through an incision parallel with and over the rib beneath which the vessel runs. The soft parts, including the artery, may be separated from the rib by a periosteal elevator, or, if necessary, a portion of the rib may be excised.

LIGATION OF THE ABDOMINAL AORTA.—Make an incision through the left rectus muscle, about four inches in length, with its centre opposite the umbilicus. Open the peritoneal cavity; press the intestines to the right; locate the aorta by its pulsation; tear through the peritoneum covering it, in order to prevent hemorrhage, being careful not to injure the vena cava and the sympathetic nerve, and pass the ligature from right to left.

Of 14 ligations of the aorta, 12 for aneurism and 2 for traumatism, all have been fatal.

LIGATION OF THE COMMON ILIAC ARTERY.—Each common iliac artery extends from its origin at the bifurcation of the aorta at the left side of the body of the fourth lumbar vertebra to the upper border of the sacro-iliac synchondrosis, being about two inches in length, the right being slightly longer than the left. The right artery crosses both the left and right iliac veins, while the left artery lies to the outer side of the left vein. The ureters cross the arteries about or just after their bifurcation into the internal and external iliac; the right artery has in front of it the ileum, while the left has in front the superior hemorrhoidal artery and the rectum. The linear guide to the vessels is a line drawn from a point a little below and to the left side of the umbilicus to a point midway between the symphysis pubis and the anterior superior spinous process.

Operation.—The common iliac may be ligated by opening the abdomen (the *transperitoneal method*), which is generally preferred, or by the *extraperitoneal method*, in which the abdominal cavity is not opened.

The Transperitoneal Method.—Place the patient in the Trendelenburg position and make an incision from three to five inches in length through the rectus muscle on the side of the artery to be ligated, the centre of the incision being a little below the umbilicus. Open the peritoneum, push the omentum and intestines upward, locate the vessel by its pulsation, and make a small opening in the peritoneum. Pass the ligature from without inward in ligating the right artery and from within outward when ligating the left artery, in both cases passing the ligature from the vein.

Extraperitoneal Method.—With the patient in the same position as for the preceding operation, make an incision from four to six inches long, from the anterior extremity of the eleventh rib downward and inward in a curved direction, ending about half an inch above the middle of Poupart's ligament. The skin, fascia, and muscles are divided until the peritoneum is exposed; this is gradually and carefully dissected up and pushed inward until the external iliac artery is exposed, care being taken not to injure the ureter. The external iliac is used as a guide to the common iliac and the ligature is passed away from the vein.

Ligation of the Internal Iliac Artery.—The internal iliac artery arises from the bifurcation of the common iliac and passes downward to the upper margin of the great sacrosciatic foramen, where it divides into the anterior and posterior trunks. It is about an inch and a half in length, and has in front the ureter and peritoneum, behind the internal iliac vein and lumbosacral nerve, and to the outer side the psoas muscle. The operation of ligation is the same as that for the external iliac, simply stripping the peritoneum up a little further and passing the ligature from within outward. The internal iliac may also be ligated by the incision for ligation of the common iliac, through the abdominal cavity.

Ligation of the External Iliac.—The external iliac artery extends from its origin at the bifurcation of the common iliac to Poupart's ligament. In front are the intestine and peritoneum, the spermatic vessels, genitocrural nerve, and circumflex iliac vein. The ureter sometimes crosses the first part of the artery. The external iliac vein is to the inner side of the artery, except that on the right side at its origin the vein is behind.

Operation.—The external iliac may be ligated by the *transperitoneal* or the *extraperitoneal* method.

The Transperitoneal Method.—Make an incision near the outer border of the rectus muscle, or open the abdominal cavity by the "gridiron" method for appendectomy.

The Extraperitoneal Method.—Make a curved incision from a point an inch above the middle of Poupart's ligament, upward and outward to a point on a level with, but two inches internal to, the anterior spine of the ilium. Divide the skin, fascia, and muscles until the peritoneum is exposed. This is stripped upward and inward until the outer border of the psoas muscle is recognized, when the vessel can be felt pulsating along the inner border of this muscle. Pass the ligature from within outward. The *deep epigastric* and *deep circumflex iliac* arteries may be ligated by means of this incision.

FIG. 11.—Ligation of external iliac and femoral arteries.

FIG. 12.—Ligation of femoral artery at the apex of Scarpa's triangle.

LIGATION OF THE GLUTEAL ARTERY.—The gluteal artery is the continuation of the posterior trunk of the internal iliac and passes out of the pelvis through the great sacrosciatic foramen above the pyriformis muscle.

Operation.—With the patient on his abdomen or side and the thigh rotated inward, make an incision four or five inches in length from the posterior spinous process of the ilium towards the trochanter major in line with the fibres of the gluteus maximus muscle. Separate the fibres of this muscle, and the artery will be found beneath, at the upper border of the pyriformis, just after its escape from the great sacrosciatic notch.

LIGATION OF THE SCIATIC ARTERY.—The sciatic artery, one of the terminal branches of the anterior trunk of the internal iliac,

passes through the lower part of the great sacrosciatic foramen *below* the pyriformis muscle and descends in the interval between the trochanter major and tuberosity of the ischium, with the sciatic nerves to its outer side and the internal pudic artery to its inner side. It is covered by the gluteus maximus muscle.

Operation.—Make an incision four or five inches in length parallel with, but about one inch and a half below, the line of the incision for ligating the gluteal artery. Separate the fibres of the gluteus maximus and find the *lower* border of the pyriformis, beneath which the artery is found.

LIGATION OF THE INTERNAL PUDIC ARTERY.—The internal pudic artery, a terminal branch of the anterior trunk of the internal iliac, passes out of the pelvis through the sacrosciatic foramen below the pyriformis muscle, crosses the spine of the ischium and re-enters the pelvis through the lesser sacrosciatic foramen, and passes along the inner surface of the rami of the ischium and pubes to its division into its terminal branches.

Operation.—The internal pudic artery may be ligated by the same incision as that for ligating the sciatic artery, it being found to the inner side of the sciatic artery; or it may be ligated in the perineum.

Operation in the Perineum.—Place the patient in the lithotomy position and make an incision three or four inches in length from a point just below the symphysis pubis to the inner side of the tuberosity of the ischium; divide the skin and fascia and be careful not to cut the *crus penis*. The artery, with its veins and nerve, can be felt pulsating about an inch and a half above the tuberosity of the ischium to the inner side of the border of the ramus.

LIGATION OF THE FEMORAL ARTERY.—The femoral artery is the continuation of the external iliac and extends from Poupart's ligament down the front and inner side of the thigh to the opening in the adductor magnus muscle, and is indicated by a line drawn from a point midway between the anterior spine and symphysis pubis to the adductor tubercle. The femoral artery may be ligated just below Poupart's ligament before giving off the deep femoral, at the apex of Scarpa's triangle, or in Hunter's canal.

Operation.—Just below Poupart's Ligament, or at the Base of Scarpa's Triangle.—With the thigh flexed and rotated outward, make an incision about two inches in length through the skin and fascia, in line with the vessel. The fascia should be divided on a director, as the vessels are superficial. The most important structures in front are the crural branch of the genitocrural nerve and the superficial epigastric and circumflex iliac veins. To the inner side is the femoral vein and to the outer side the anterior crural nerve.

The trunk of the common femoral artery is only an inch and a half or two inches in length before it divides into the superficial femoral and the profunda. Open the sheath of the vessels carefully and pass the ligature from within outward.

At the Apex of Scarpa's Triangle.—This is the point of election. The *base* of Scarpa's triangle is formed by Poupart's ligament, its *inner* side by the adductor longus, and its *outer* side by the sartorius muscle. The femoral artery passes through the middle of the triangle from base to apex. It has in *front* the skin, fascia, and internal cutaneous nerve; *behind*, the femoral vein, the profunda artery and vein, and muscles; to the *outer* side, the anterior crural and long saphenous nerves; and to the *inner* side, the femoral vein before becoming posterior. *Operation.*—With the thigh flexed and rotated outward, make an incision in the line of the artery, three inches in length, beginning three inches below Poupart's ligament. On dividing the skin and fascia the edge of the sartorius muscle will be exposed, and on drawing it to the outer side the sheath of the vessels is seen. Open the sheath and pass the ligature from within outward. (See Fig. 12.)

In Hunter's Canal.—This is a space occupying the middle third of the thigh, extending from the apex of Scarpa's triangle to the opening in the adductor magnus muscle. It is formed by an aponeurosis extending from the vastus internus on the outer side to the adductor longus and magnus muscles on the inner side. The femoral artery and vein, enclosed in a sheath, pass beneath this aponeurosis with the internal saphenous nerve, the vein being behind and to the outer side of the artery. *Operation.*—With the thigh flexed and rotated outward, make an incision four inches in length in the line of the artery from the junction of the upper and middle third of the thigh downward, being careful to avoid the internal saphenous vein. On dividing the skin and fascia, the sartorius muscle comes into view and should be drawn to the inner or outer side. This exposes the roof of Hunter's canal, which is cautiously opened, when the saphenous nerve is seen lying on the sheath of the vessels or to its outer side. Open the sheath and pass the ligature from without inward, avoiding both nerve and vein.

Anomalies.—Sometimes two femoral arteries are found in Hunter's canal, which unite before passing through the opening in the adductor magnus muscle. Occasionally the femoral artery is continuous with the internal iliac and runs down the back of the thigh with the great sciatic nerve. There are anomalies also as to number and position of the femoral vein.

LIGATION OF THE POPLITEAL ARTERY.—The popliteal artery

extends from the opening in the adductor magnus to the lower border of the popliteus muscle, where it divides into the tibial arteries. The artery rests on the lower part of the femur, the posterior ligament of the knee-joint, and the popliteus muscle covering the upper part of the tibia. Superficial to or behind the artery are the popliteal vein and internal popliteal nerve, the latter crossing the artery from without inward. The popliteal artery gives off eight branches to the joint and muscles.

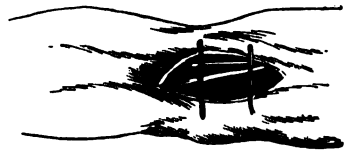


FIG. 13.—Ligation of the popliteal artery.

Operation.—The artery is most accessible in its first portion. With the patient lying on his face or side, make an incision four inches in length along the middle of the popliteal space to the knee-joint. Divide the skin and fascia until the outer border of the semimembranosus muscle is exposed. On drawing this inward and separating the areolar tissue, the nerve is seen crossing from without inward, and just beneath, covering the artery, the popliteal vein. The nerve and vein should be drawn to the outer side and the ligature passed from without inward.

LIGATION OF THE POSTERIOR TIBIAL ARTERY.—The posterior tibial extends from the bifurcation of the popliteal artery down the tibial side of the back of the leg, lying on the tibialis posticus and flexor longus digitorum muscles to the space between the internal malleolus and tuberosity of the os calcis, where it divides into the internal and external plantar arteries. It is accompanied by venæ comites and the posterior tibial nerve, which crosses its first portion

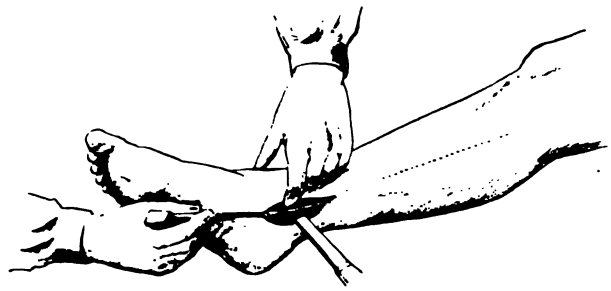


FIG. 14. Ligation of the posterior tibial artery.

from within outward and then lies to its outer side. The artery may be ligated in its upper or middle third, or behind the internal

malleolus. The course of the vessel is indicated by a line drawn from the middle of the popliteal space to a point midway between the internal malleolus and the tuberosity of the os calcis.

Operation.—In the Upper Third.—With the patient on his back and with the leg flexed on the thigh, make an incision three or four inches in length, three-quarters of an inch (or a finger's breadth) behind the internal border of the tibia, beginning two inches below the head of the bone. Divide the skin and fascia, avoiding the internal saphenous vein, detach the tibial origin of the soleus muscle, and retract it backward and outward. Divide the fascia thus exposed and search for the artery towards the middle of the leg on the tibialis posticus muscle. Separate it from the veins and nerve and pass the ligature from without inward.

In the Middle Third.—With the patient in the same position, make an incision three inches in length, three-quarters of an inch behind the internal border of the tibia, in the middle third of the leg. Divide the skin and fascia until the inner border of the soleus muscle is found. Retract this outward and find the space between it and the flexor longus digitorum, in which the artery with its two veins and nerve to the outer side will be found.

Behind the Internal Malleolus.—Here the artery has its two veins, one in front and one behind, with the posterior tibial nerve next behind and still further behind the flexor longus hallucis. Anteriorly are the tendons of the flexor longus digitorum and tibialis posticus. Make an incision two inches in length midway between the tendo Achillis and the internal malleolus. Divide the skin, deep fascia, and internal annular ligament carefully, when the artery will be exposed.

LIGATION OF THE PLANTAR ARCH.—The plantar arch is formed by the external plantar artery, which extends from its origin at the bifurcation of the posterior tibial forward and outward in the sole of the foot to the base of the fifth metatarsal bone, then obliquely inward to the interval between the bases of the first and second metatarsal bones, where it anastomoses with the communicating branch from the dorsalis pedis. The arch may be ligated by an incision along the outer border of the sole of the foot, or by a dorsal incision with resection of a portion of the second, third, or fourth metatarsal bone (De Lorme).

LIGATION OF THE PERONEAL ARTERY.—This artery, a branch of the posterior tibial, extends from that vessel about an inch below the lower border of the popliteus muscle obliquely outward to the fibula, then downward along the inner border of the fibula to the lower third of the leg. It has in front the tibialis posticus

and flexor longus hallucis muscles, and has behind the soleus and the flexor longus hallucis, the latter surrounding the artery for the greater portion of its course.

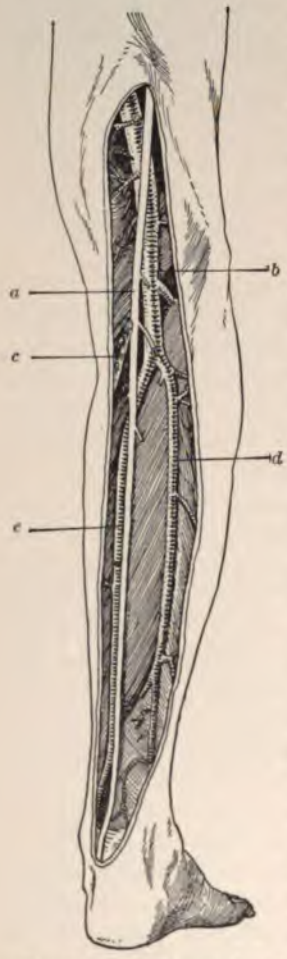


FIG. 15.—Popliteal, posterior tibial, and peroneal arteries: *a*, popliteal nerve; *b*, popliteal artery; *c*, cut edge of soleus muscle; *d*, peroneal artery; *e*, posterior tibial artery and nerve. (After Gray.)

Operation.—Make an incision three or four inches in length along the outer side of the leg, half an inch posterior to the fibula. Divide the skin and fascia and find the space between the soleus and flexor longus hallucis muscles. The artery is found at the inner side of the flexor longus hallucis.

LIGATION OF THE ANTERIOR TIBIAL ARTERY.—The anterior tibial extends from the bifurcation of the popliteal forward between the tibia and fibula above the interosseous membrane, descends on the anterior surface of this membrane, gradually approaching the tibia, on which it lies at the lower part of the leg, then on the anterior ligament of the ankle to the ankle-joint, where it becomes the dorsalis pedis. The course of the vessel is indicated by a line drawn from the inner border of the head of the fibula to a point on the anterior surface of the ankle midway between the two malleoli. It may be ligated in the upper, middle, or lower third.

Operation.—In the Upper Third.—Make a three-inch incision along the line of the artery, beginning about one inch below the head of the fibula. Divide the skin and fascia and find the intermuscular space of the tibialis anticus and extensor longus digitorum. The artery is found deep down, with the anterior tibial nerve on the outer side and accompanied by its venæ comites.

In the Middle Third.—The artery lies between the tibialis anticus and the extensor proprius hallucis, with the anterior tibial nerve lying on its front. Make a three-inch incision in the line of the artery in the middle third of the leg. Divide the skin and fascia and find the artery in the space between the tibialis anticus and the extensor proprius hallucis.

In the Lower Third.—Here the artery is crossed by the tendon of the extensor proprius hallucis, and lies between it and the tendon of the extensor longus digitorum, with the anterior tibial nerve to the outer side. To ligate the artery above the point where it is crossed by the extensor proprius hallucis extend the foot and make a two and one-half inch incision in the lower third of the leg to the outer side of the tendon of the tibialis anticus. Divide the skin and fascia, and find the space between the tibialis anticus on the inner side and the extensor proprius hallucis on the outer side just above where it crosses the artery. Pass the ligature from without inward.

LIGATION OF THE DORSALIS PEDIS ARTERY.—The dorsalis pedis is the continuation of the anterior tibial, and extends from the bend of the ankle along the tibial side of the foot to the back part of the first intermetatarsal space, where it divides. It has along its inner side the tendon of the extensor proprius hallucis, on its outer side the extensor longus digitorum and anterior tibial nerve, and is crossed near its termination by the innermost tendon of the extensor brevis digitorum. Make a two-inch incision from the middle of the front of the ankle-joint towards the first intermetatarsal space, using the tendon of the extensor proprius hallucis as a guide. Pass the ligature from without inward.

CHAPTER VII.

AMPUTATIONS.

Amputation means the cutting off of any part, but as generally understood it means the cutting off of an extremity or a portion of an extremity. When the division is made through a joint it is called disarticulation.

CLASSIFICATION.—According to the time after injury amputation may be: *Primary*, when performed immediately after the injury, before the development of fever or suppuration, usually less than three days; *intermediate*, when performed during the inflammatory or early suppurative period, before toleration has become established, usually the first ten days after the injury; and *secondary*, when the operation is performed after the subsidence of the acute symptoms; although suppuration may be well established, the patient has acquired a kind of tolerance.

The *primary* period is always to be preferred, but, for obvious reasons,—uncertainty as to the necessity of sacrificing a limb or the refusal of the patient,—the surgeon may be forced to operate during the intermediate or the secondary period. The *secondary* period is next choice after the primary, the *intermediate* being avoided, except when the patient's life is threatened by the development of septicæmia, the extension of a gangrenous process, or his vitality is in all probability not sufficient to endure the drain or prolonged confinement in bed.

INDICATIONS.—*Compound fractures and dislocations*, the results of injury by machinery or railroad cars, are the most frequent conditions requiring amputation. Some other conditions are: *Malignant growths*, cancer or sarcoma; *gangrene*, when involving the extremities; the *effects of extremes of temperature; gunshot injuries* with extensive destruction of the bones, joints, blood-vessels, and nerves; *diseases* of *bones* and *joints*, such as osteomyelitis and arthritis, when resection will not suffice; *diseases of blood-vessels*, as some aneurisms; and incorrigible *deformities* which disable the patient and which are situated so that an artificial limb will be more satisfactory.

INSTRUMENTS.—The instruments required are:

A tourniquet, or apparatus for preventing hemorrhage.

A long knife, for the amputation of large limbs, especially if the method by transfixion be used.

A scalpel, for dissecting up skin flaps and for amputating small extremities.

A catlin, or long double-edged knife, for cutting between bones.

A retractor, or strip of cloth about the size of a large towel, with one end split into two or three tails, in order to retract and prevent injury to the soft parts while sawing the bone.

A strong, sharp saw.

Bone-cutting forceps, for trimming rough edges.

A periosteal elevator.

Lion-jawed forceps, for holding the bone steady.

A sufficient number of hæmostatic forceps.

Ligatures of catgut and silk.

Needles.

Needle-holder.

Drainage tubes.

Dressings.

For preventing hemorrhage Petit's tourniquet or Esmarch's rubber bandages, or some modification, are used.

Petit's tourniquet consists of two metal plates, the distance between which is regulated by a screw, with a strong strap of linen or cotton provided with a buckle. The tourniquet is applied by placing a pad over the main artery of the limb and buckling the tourniquet around the limb so that the lower plate rests upon the pad over the artery in a drection to press the artery against the bone, which is done by turning the screw. Either the screw of the tourniquet, or when this is impracticable, the point in the tourniquet directly opposite the screw, should be placed on the pad over the artery, as these are the only two points in the tourniquet which are fixed; and a pad placed under any intermediate portion of the strap would have a tendency to be pulled away from the artery when the screw is tightened.

FIG. 16.—Petit's tourniquet.

Esmarch's apparatus, which is usually preferred to all others, consists of a broad, thin, but strong rubber bandage and a rubber tube or

strap. By its use the blood in the extremity can be forced out of the limb to be operated on into the general circulation and the operative field rendered bloodless; but this must not be done when there is

FIG. 17.—Esmarch's apparatus.

danger of forcing infectious material into the general circulation. The bandage is first wound around the limb, beginning at its distal extremity, and carried upward, each turn being drawn firmly and overlapping the preceding turn by one-half or one-third, to a point well above the site of operation, where two or three turns of the rubber *tube* or *strap* are made sufficiently tight to arrest the circulation, and the

FIG. 18.—Esmarch's apparatus applied.

rubber bandage is removed. The rubber tube should not be kept in place too long, especially in operations not requiring amputation, lest important blood-vessels and nerves be permanently injured by the constriction.

METHODS OF OPERATING.—In shaping the soft parts for covering the bone and forming a stump two methods are used,—namely, the *circular* and the *flap*,—and all others are modifications of these.

The Circular Method.—The surgeon stands so as to grasp the limb with the left hand on the side next to the patient's body, retracts the skin towards the body, and makes a circular incision through the skin and fascia down to the muscles at a point below the proposed division of the bone equal to one-fourth the circumference of the limb. In all cases the combined length of the *two* flaps should be

a little more than the diameter of the limb and to allow for retraction they should equal one-half the circumference. The incision may be made with a small knife, or else by using a long one and making but one stroke, placing the hand which holds the knife beneath the limb, then bringing it over until the back of the knife faces the

FIG. 19.—Amputation by circular method. (After Esmarch.)

operator when the incision begins, cutting first with the heel of the knife and completing the circumcision with its point. The skin is retracted in the form of a cuff by dissecting the cellular tissue from the muscles, keeping the edge of the knife turned towards the muscles to avoid injuring the circulation in the skin. It is often necessary, on account of the conical shape of the limb, to split the cuff on its most dependent side. After retraction of the skin to a sufficient distance, the muscles are divided by a circular cut through all the tissues down to the bone, the soft parts are retracted and protected, while the bone is divided with the saw.

FIG. 20.—Amputation by modified circular method. (After Esmarch.)

Modified Circular Method.—The circular may be changed into the modified circular by splitting the sides of the skin-cuff and rounding

off the corners. A single longitudinal incision with rounding off of the corners makes the transverse racket-flap.

The *elliptical* or *oval method* is a variety of the circular method in which the incision makes an ellipse, the two ends of which are on different levels and on the opposite sides of the limb, and when the flap is folded on itself it makes a curved cicatrix.

The *racket method* is another variety of the circular, in which a circular or oval incision is made around the limb, connected with a longitudinal incision which corresponds to the handle of a racket.

The Flap Method.—The flap method may consist of two flaps of equal length, two flaps of unequal length, or a single flap. They may be cut anteroposteriorly, laterally, or obliquely, and may be curved or rectangular in shape. They may be made by cutting from

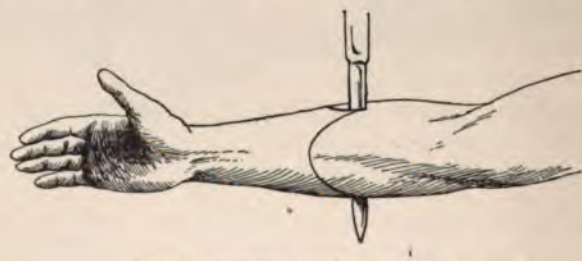


FIG. 21.—Forming flaps by transfixion.

without inward, or by transfixing and cutting from within outward, and may be composed only of skin and connective tissue, or of skin, connective tissue, and muscle.

INDICATIONS FOR THE DIFFERENT METHODS. — The *circular* method, in which only skin flaps are used, is suitable for amputations through the upper extremity; but in the lower extremity where an artificial limb is to be worn, the flap method containing muscle is generally preferred as affording a thicker padding over the end of the bone. The *elliptical or oval method* is suited for disarticulation at the knee or elbow, the *racket method* for disarticulation of the metacarpo- or metatarso-phalangeal joints. When for any reason the flap must be obtained from one side of the limb, the single flap method is used, and when the tissues have been extensively destroyed an irregular flap may be necessary.

TECHNIQUE OF AN AMPUTATION.—The patient should not be operated on during the existence of shock, except in those cases in which the shock is maintained by the presence of a mangled limb. The parts having been thoroughly disinfected, anæsthetize the patient and place him upon the operating table, with the injured or diseased

limb projecting over the edge of the table. The instruments, after sterilization, are placed within reach of the surgeon. Four or five assistants are required; one to give the anæsthetic, one to hand the instruments, one to handle the sponges, one or two to hold the limb, and one for general utility, having charge of the hot water and the irrigating and salt-infusion apparatus. The circulation in the limb

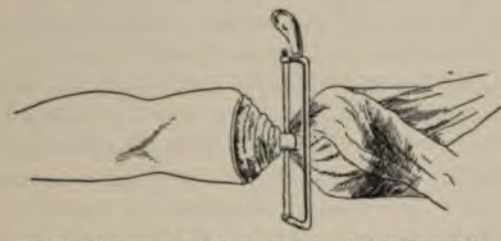


Fig. 22.—Retractor and saw applied. (After Esmarch.)

having been arrested by Esmarch's apparatus or Petit's tourniquet, the surgeon takes his position with his left side towards the patient's body, grasping the proximal portion of the limb, while an assistant holds the distal portion. Another assistant stands ready to aid in holding the proximal portion of the limb and to use the retractor at the proper time. Having decided on the method of amputation and estimated the position and length of the flaps, the surgeon proceeds until the soft parts have been divided to the bone. The bone is cleaned of soft tissues over a sufficient space for the use of the saw. A periosteal flap is unnecessary. The retractor is then applied, protecting the soft parts and retracting them above the point where the bone is to be divided. This is done by rapid motions of the saw, while the two assistants hold the limb steady and prevent pinching the saw. The bone is sawed across at right angles to its long axis, and where two bones of unequal size are divided the smaller one is divided first, to avoid breaking and splintering. Any splinters or rough edges left are trimmed with bone-forceps. The arteries are secured by hæmostatic forceps and tied with catgut ligatures. After securing all the vessels which can be found, the elastic tube is removed and any new points of hemorrhage ligated. Hemorrhage from points where no vessel can be found is arrested by a suture-ligature. General oozing is arrested by the use of hot water or by compression, placing the flaps in position and compressing the parts for a few minutes. All exposed nerves and tendons are drawn out for a short distance and cut off. After arresting hemorrhage the muscular portion of the flap may be united over the end of the bone by catgut sutures and the skin united by interrupted sutures of silkworm gut

placed at intervals of half an inch and supplemented by a continuous suture of silk or silkworm gut, in order to bring the edges of the skin into accurate approximation. It is a good rule to use a rubber drainage tube, or in large limbs two tubes, one projecting out of each side of the stump.

Although healing often takes place without the use of a drainage tube, yet in many cases sufficient oozing occurs to distend the flaps and require a long time for absorption, even if suppuration does not occur in such an excellent culture medium for bacteria.

An abundance of sterile gauze is applied over the stump and limb for at least ten or twelve inches above, and over this a thick layer of cotton, and the whole secured by a firmly applied bandage carried high enough to prevent all danger of slipping, or secured by strips of adhesive plaster attached to the bandage and to the skin above. The patient is then put to bed and the stump placed on a soft pillow with a frame over it to protect it from the weight of the cover.

AFTER-TREATMENT.—If there is much shock and reaction is slow, use rectal injections or venous infusion of hot salt solution. Hypodermatic injections of strychnine may also be given, and warm applications in the form of bottles of hot water applied to the patient, but they should not come in contact with the skin, and great care is necessary to prevent burning. Morphine should be avoided, unless the pain is quite severe. If the dressings are not soiled, and the pulse and temperature are satisfactory, the dressings need not be disturbed before the end of the week. Elevation of temperature, rapidity of pulse, or soaking through of the dressing requires change of dressings without further delay. Each dressing must be made under the same aseptic and antiseptic precautions as were observed during the operation. The drainage tube is removed at the first dressing after the cessation of discharge, and the stitches at the end of ten days or two weeks.

After amputations of the hands or feet, or even of the arms, the patient need not be kept in bed longer than a week or ten days. In amputations higher up he is kept in bed from two weeks to a month. Occasionally hemorrhage occurs within two or three days (intermediary), or after a week or ten days (secondary), and requires prompt treatment. If not severe, elevation of the stump and the firm application of a compress and bandage may be sufficient; if profuse or continuous, the wound should be opened and the bleeding vessels ligated.

Conical Stump.—Conical stump may be the result of short flaps, or in children, from excessive growth of the bone as compared with

the soft parts. In the latter prevention is impossible; in both, the treatment is reamputation.

MORTALITY FROM AMPUTATION.—The mortality from amputation is influenced by many conditions: the locality of the amputation; the number of amputations; whether for injury or disease, and, if the latter, whether acute, chronic, or malignant; the age of the patient and his general condition as to disease of internal organs, loss of blood, or other complications. Amputations of the lower extremity give a higher mortality than those of the upper extremity, and in either case the mortality increases in proportion to the proximity to the trunk, as the shock seems to be greater. Young persons and children bear operations better than the aged. Amputations for acute disease, as arthritis or osteomyelitis, have a higher mortality than those for chronic disease, and amputations for injury have a higher mortality than those for disease. Certain general conditions have an unfavorable influence, as Bright's disease, diabetes, or severe hemorrhage. Sepsis is a rare cause of death since the general practice of aseptic and antiseptic surgery, except in cases infected previous to operation. Gangrene of the flaps may result from injury in railroad or other accidents, because the amputation was not made above the devitalized tissues. Acute traumatic spreading gangrene may result from infection with the bacillus of malignant œdema, the bacillus aerogenes, and probably others. The mortality varies from 1 to 5 per cent. in the hands and feet to from 25 to 75 per cent. at the hip-joint.

MULTIPLE AMPUTATIONS.—On account of railroad and machinery injuries, it is sometimes necessary to amputate two, three, or four limbs at the same time. Many patients have recovered after amputation of two limbs, some after triple, and a very few after quadruple amputations. Usually, however, the severity of the injury, with the shock and hemorrhage, causes a fatal termination when it is necessary to amputate more than one limb at the same time.

When multiple amputations are necessary, the "consecutive" method, as recommended by Ashhurst, is probably better than the "synchronous" method in which two or more surgeons operate at the same time.

In Ashhurst's consecutive method the amputations are performed successively, beginning with the most severe, which is the test as to whether the patient will bear further operation. To shorten the time of anæsthesia and diminish shock, the operations should be performed rapidly, not stopping to suture the flaps, but, after ligating the blood-vessels, wrap the stump in a sterile towel and perform the next operation, and after all have been done put in the sutures.

racket incision, beginning on the dorsal surface of the metatarsal bone of the great toe, for example, at its articulation with the cuneiform, cutting downward to a little beyond the metatarsophalangeal articulation, at which point the incision is carried around the toe. The bone is freed from the soft parts by disarticulating it at its base, cutting the extensor and flexor tendons and the peroneus longus, and is removed with the toe. The wound is closed by uniting the edges, and makes a linear scar on the dorsal surface.

AMPUTATION AT THE TARSOMETATARSAL ARTICULATION.—In amputations of the foot and ankle the circulation should be controlled by Esmarch's constrictor applied around the leg about two inches below the head of the fibula.

Lisfranc's Method.—This is the only method in which a complete disarticulation at the tarsometatarsal joints is performed, all the modifications involving the division of some of the metatarsal or tarsal bones in continuity. The surgeon places the thumb and forefinger of the left hand on the base of the metatarsal bone of the little toe and the tuberosity of the scaphoid, and makes a dorsal flap about one inch in length by a curved incision extending from half an inch in front of the tuberosity of the scaphoid across the foot to the base of the fifth metatarsal bone. The flap of skin and fascia is dissected back until the articulations are exposed, when the tendons and muscular fibres are divided and the joints opened by means of a stout, narrow-bladed knife, beginning with the joint between the fifth metatarsal bone and the cuboid, disarticulating in succession the fourth and third and then the first before attacking the second metatarsal, which articulates with the middle cuneiform in a mortise formed by the other cuneiform bones. Disarticulation of the second metatarsal is accomplished by forcibly depressing the anterior portion of the foot and cutting across and then on either side of the joint. After opening all the joints the plantar ligaments are divided, a long knife is passed behind the bases of the metatarsal bones, and a plantar flap is cut from within outward, terminating near the bases of the toes. If preferred, the plantar flap may be made by cutting from without inward. Ligate the dorsalis pedis, the interosseous, and the internal and external plantar arteries and their branches. Trim the plantar flap in order to make it fit, retrench it if too thick, and attach it to the dorsal flap by means of sutures.

Modifications of Lisfranc's Operation.—1. *Hey's.*—This operation is the same as Lisfranc's except that the projecting portion of the internal cuneiform bone is sawed off after disarticulating the four external metatarsal bones. 2. *Skey's Method.*—Skey saws off the base of the second metatarsal bone, leaving it in the mortise.

AMPUTATION OF THE METACARPAL BONE WITH ITS FINGER OR THUMB.—Make an incision from the base of the metacarpal bone to

FIG. 24.—Disarticulation of finger by long anterior flap. (After Esmarch.)

FIG. 25.—Showing position of joints when flexed. (After Smith.)

its head, thence an oval incision around the base of the phalanx to be removed. Dissect the soft parts from the bone on each side and beneath, and disarticulate the metacarpal bone at its base.

AMPUTATION OF THE HAND AT THE CARPOMETACARPAL JOINT, LEAVING THE THUMB.—With the hand supinated, insert the point of a long, narrow knife at the base of the metacarpal bone of the little finger, and carry it across the palmar surfaces of the metacarpal bones of the fingers, emerging just below the thumb. Carry the knife downward close to the metacarpal bones, then forward, making an elliptical flap. Make a short dorsal flap and disarticulate the metacarpal bones from the carpus, or saw them across beyond the bases. In all amputations of the hand the palmar flap is preferred as a covering to the stump, and if possible it should be made long enough to avoid cutting either of the palmar arches.

AMPUTATION AT THE WRIST.—The operation may be done by the *circular*, the *double flap*, or the *single palmar flap* method. In many cases the flap must be obtained from any available tissue. The preferable method is by a long palmar and a short dorsal flap. An Esmarch's apparatus or a Petit's tourniquet may be applied over the brachial artery in the middle of the arm. With the hand flexed make a curved incision on the dorsum, the convexity forward, from one styloid process to the other, making a flap one-half to three-quarters of an inch in length. Turn the flap back, cut the posterior radiocarpal and the two lateral ligaments, disarticulating the joint, and make a palmar flap about two inches long by cutting downward and forward. The radial, ulnar, and interosseous arteries require ligation.

AMPUTATION OF THE FOREARM.—Amputation of the forearm may be made in the lower, middle, or upper third by the *equal flap*

method, by a *long dorsal* and *short anterior* flap, or by the *circular* or *modified circular* method, using skin only for flaps, or both skin and muscle. The *modified circular* is usually preferred. With the tourniquet or Esmarch's constrictor applied over the brachial artery, make a circular incision, split the skin on one or both sides, round off the corners, turn back the cuff or flaps, divide the muscles by a circular incision to the bone, pass a catlin between the bones to divide the interosseous tissues, retract the soft parts, and saw the two bones at the same time. Ligate the radial, ulnar, anterior and posterior interosseous arteries, and unite the flaps.

DISARTICULATION AT THE ELBOW.—Disarticulation at the elbow may be performed by one of three methods,—the *circular*, the *elliptical*, anterior or posterior, and the *flap method*, the flaps being lateral or anteroposterior, in the latter case one being longer than the other.

The Circular Method. — Make an incision around the forearm, through the skin and fascia, down to the muscles at a point below the external condyle, equal to one-fourth the circumference of the limb. The incision should be made somewhat obliquely, being one inch nearer the external than the internal condyle. Dissect up the cuff until the joint is exposed. Extend the arm, make an oblique incision in front of the joint, dividing the ligaments in front and at the sides, and draw the olecranon forward until the attachment of the triceps to it can be divided. Some advise sawing off the olecranon in order to retain the insertion of the triceps, or, still better, if possible, dividing the ulna below the insertion of the brachialis anticus muscle. Ligate the brachial artery and unite the flaps transversely or anteroposteriorly.

The Elliptical Method.—In this method a single flap is made either from the front or back of the forearm, the anterior ellipse being made as follows: Beginning at the olecranon process, carry the incision downward and forward, crossing the forearm in front just above the middle, then proceeding upward and backward to the point of beginning. The flap is dissected up and the forearm disarticulated. The two sides of the flap may be united, making a linear cicatrix; or the flap may be folded on itself and united, making a semilunar cicatrix.

The Anterior Single Flap Method.—This may be made either by transfixion or from without inward, the flap being taken from the anterior surface of the forearm and being equal in length to one-half the circumference of the elbow, the radial side being somewhat shorter. The posterior flap is made by connecting the extremities of the first incision, and should be about one inch in length. Dissect up the flap and disarticulate, beginning either in front or behind.

AMPUTATION OF THE ARM.—Amputation of the arm may be

done by the *circular*, *modified circular*, or any variety of the *flap* method. The circular or modified circular is usually preferred. The circulation is arrested by a tourniquet over the brachial artery, but when there is not sufficient room for a tourniquet on the arm Wyeth's method of preventing hemorrhage in amputation at the shoulder-joint may be used (see AMPUTATION AT THE SHOULDER-JOINT), or pressure by means of a padded key or compress on the subclavian artery where it crosses the first rib. In making muscular flaps do not forget that the anterior, containing the biceps muscle, contracts more than the posterior, containing the triceps muscle.

The Circular Method.—With the arm abducted and held by an assistant, the surgeon takes hold with his left hand on the proximal side and with one sweep of the knife divides the skin and cellular tissue at a point below the proposed section of the bone equal to one-fourth the circumference of the limb. Turn back the cuff of skin and divide the muscles in the same manner down to the bone. Apply a two-tailed retractor, retract the soft parts, and saw the bone. Tie the brachial artery,—remember the possibility of a high division of this vessel,—the superior profunda artery, and, in the lower third of the arm, the inferior profunda artery. In addition there are usually several muscular branches which require ligatures. Draw down and cut off the ends of the musculospiral, median, and ulnar nerves. Remove the tourniquet, arrest any further hemorrhage, and close the wound, leaving a rubber or glass drainage tube in the most dependent portion.

The Conical Method.—By dividing the muscles in two layers at different levels, a conical-shaped cavity is made, with the base below and apex above, corresponding with the end of the bone. The skin is divided and retracted as in the circular method. The muscles are then divided half-way to the bone by a circular incision, retracted, and the remaining half divided at this level down to the bone.

Modified Circular Method.—The flaps may be obtained from the sides or from the anterior and posterior parts of the arm. The flaps are cut elliptical in shape dissected up the proper distance, and the muscles divided by a circular incision down to the bone.

Transfixion Method.—The flaps may be made by transfixion and contain both muscle and skin. The surgeon grasps the arm with the left hand, pulling up the flesh on the back of the arm, and thrusts the point of a medium-sized amputating knife through the arm, just grazing the bone behind and emerging opposite the point of entrance. The knife is carried downward parallel with the bone for a sufficient distance, then outward, making a posterior flap. The knife is then entered in front of the bone and an anterior flap cut in the same

manner. The flap last cut should contain the principal artery. The flaps are retracted by a two-tailed retractor, and the bone is cleaned of the soft tissues and divided with the saw.

Teale's method is sometimes performed in the lower third of the arm, making a long square posterior flap and a short anterior flap which contains the nerves and brachial artery.

AMPUTATION AT THE SHOULDER-JOINT.—The principal methods of disarticulating at the shoulder-joint are the *racket* (Larrey and Spence), the *flap* (Dupuytren and Lisfranc), and the *circular*. In any method control the circulation by Wyeth's pins and a rubber tube or strap, as follows: With the arm placed at right angles with the body, introduce a steel skewer, ten or twelve inches in length, through the anterior axillary fold, a little to the thoracic side of its middle, and let the point emerge one inch to the inner side of the tip of the acromion process. A second skewer is passed through the posterior axillary fold near the body so that its point emerges one inch internal to the tip of the acromion process. The points of the skewers are guarded with sterile corks. A rubber tube about half an inch in diameter is tightly wound two or three turns around the shoulder between the skewers and the body, and its ends are secured by tying or clamping. Examine the radial and brachial arteries to see if the circulation is completely arrested. Other methods of controlling the circulation are by direct pressure over the subclavian where it crosses the first rib, or by preliminary ligation of this vessel.

FIG. 26.—Amputation at shoulder. (Larrey.)

The Racket Method (Larrey).—With the arm extended at right angles, make an incision from the tip of the acromion process downward along the humerus for about three inches. From just below the middle of this incision make two others—one on each side, obliquely downward, respectively—to the points of junction of the anterior and posterior axillary folds with the humerus, the soft parts containing the axillary artery and nerves remaining undivided. The flaps are dissected up until the joint is exposed, opened above, the head of the bone dislocated and a knife passed behind it, cutting downward and inward until the remaining tissues at the inner side of the humerus are divided. Ligate the axillary artery and vein and several small arteries, remove the constriction, arrest further hemorrhage, and unite the flaps vertically, leaving a drainage tube in the lower angle of the wound.

Spence's Method.—This is a variety of the racket method and is

somewhat like Larrey's, but the handle of the racket is longer and therefore the flaps are longer. This method may be used when it is doubtful whether excision of the joint or amputation will be necessary. Make an incision down to the bone, beginning just external to the coracoid process, straight down the humerus, through the deltoid and insertion of the pectoralis major, then obliquely outward to the posterior border of the axilla. An inner incision is carried in like manner to the anterior border of the axilla. The humerus is disarticulated and the remaining portion of the soft tissues divided as in Larrey's method.

The Flap Method (*Dupuytren*).—In this method a long external flap is made from the deltoid, with a short internal flap containing the

Fig. 27.—Amputation at shoulder-joint. (Dupuytren.)

principal artery and nerves. The flaps may be made by transfixion or by cutting from without inward. With the arm extended, make an elliptical external flap by an incision extending from the coracoid process downward and outward, to the insertion of the deltoid, then upward and backward to the junction of the acromion process with the spine of the scapula. Dissect up the flap thus made until the capsule of the joint is exposed, divide the capsule and the muscles attached to the greater and lesser tuberosities of the humerus, until the head of the bone can be dislocated. The internal flap is then made by carrying the knife along the inner side of the bone until just below the axillary fold, when the section is completed by cutting inward.

The Flap Method (*Lisfranc*).—In this method an antero-external and a postero-internal flap are made by transfixion. The point of a long knife is entered at the outer side of the coracoid process and, while the skin and muscle are lifted with the left hand, is carried across the outer part of the joint, emerging a little below the posterior border of the acromion process, and a long flap is cut from above downward and outward. This flap is dissected up, the head of the bone disarticulated, the knife entered behind the bone, and a long postero-internal flap, which contains the blood-vessels, is made in the same manner.

The Circular Method.—Make a circular incision completely dividing all the soft tissues down to the bone at the level of the insertion of the deltoid, divide the bone at the same level, and ligate the vessels. Make a longitudinal incision to the bone from the anterior border of the acromion process to the end of the stump and dissect out the bone, freeing it from the soft parts by rotating it first inward then outward in order to divide the muscles attached to the greater and lesser tuberosities.

AMPUTATION ABOVE THE SHOULDER.—This may be required on account of severe injury or malignant disease. In some cases a portion both of the clavicle and scapula may be left, but in others the entire upper extremity, including the clavicle and scapula, is removed. This may be done by Paul Berger's method.

The Interscapulo-thoracic Amputation.—Make an incision from the inner extremity of the clavicle outward to the top of the shoulder, exposing the clavicle from one end to the other. The clavicle is removed either by dividing it and disarticulating each end, or it may be removed without division. The subclavian artery and vein are tied, each by two ligatures about an inch apart, and the vessels divided between the ligatures. The axillary plexus of nerves is also divided. A second incision is made, beginning at the centre of the first incision and extending it across the anterior part of the axilla and inner side of the arm to the inferior angle of the scapula. The outer extremity of the first incision is then extended posteriorly across the dorsum of the scapula to its inferior angle, joining the termination of the second incision. The posterior flap thus made is dissected back and the connections of the scapula with the trunk are divided by an incision along the vertebral border of the scapula, severing the trapezius, the levator anguli scapulæ, and the rhomboid muscles. The arm and scapula are pulled forward and the amputation completed by division of the pectorales and the latissimus dorsi. Arrest all hemorrhage, introduce a drainage tube, suture the flaps, and apply a dressing with compresses in order to obliterate all dead spaces.

AMPUTATIONS OF THE LOWER EXTREMITY.

AMPUTATION OF THE TOES.—The phalanges being so short, amputation of the toes, with the exception of the great toe, is usually made through the joints. Interphalangeal amputation is performed in the same manner as in the fingers,—namely, by a long plantar and a short dorsal flap, or two lateral flaps. The incision should be made so as to avoid a cicatrix on the plantar surface.

Metatarsophalangeal Disarticulation.—This is done by means of the *racket* incision, as in the corresponding amputation of the fingers. It is important to remember that the web of the toes extends to a considerable distance below the metatarsophalangeal joints.

Disarticulation of the Great and Little Toes.—This may be done by the *racket*, the *lateral* flap, or the *long planter* and *short dorsal flap* method. The head of the metatarsal bone of the great toe should not be removed unless absolutely necessary, and care should be taken to have the flaps sufficiently long to provide for it ample covering without tension.

Amputation of Two Toes Together.—Make a dorsal incision between the metatarsal bones of the toes, beginning just below the metatarsophalangeal joints, and carry it downward and outward around one of the toes, through the digito-plantar fold, around the other toe, back to the point of starting. Dissect the flap back, disarticulate the toes, and suture the flap.

Amputation of all the Toes.—Make a short dorsal flap by an incision across the bases of the toes on a level with the web. Dissect back the flap, disarticulate the toes from the dorsal surface, flex them, and cut a plantar flap from the under surface of the phalanges as far forward as the web of the toes. If preferred, both flaps may be made by cutting from without inward. Care should be taken to provide sufficient flap to cover the head of the metatarsal bone of the great toe, prolonging the flap along the under surface or inner side of the great toe when possible.

AMPUTATION OF ALL THE METATARSAL BONES.—Amputations of the metatarsal bones are made by preference *in continuity*, to avoid opening the tarsal articulations. The operation is best performed by making a short dorsal flap, convex forward, and a long plantar flap, beginning at the web of the toes and dissecting back to the point at which the bones are to be divided. The interosseous tissues are divided with a narrow-bladed knife and a six-tailed retractor is used while the bones are sawed.

AMPUTATION OF THE GREAT TOE OR OF THE LITTLE TOE WITH ITS METATARSAL BONE.—This is performed by means of a *long-handled*

flap by carrying the knife downward and outward. Then make an internal flap about one-fourth the length of the external, by cutting from without inward through the skin and muscles.

Bier's Method.—In order to make a stump which will bear pressure well and not be prone to atrophy, Bier makes a second operation after the healing of the wound, in which he removes a wedge-shaped portion of the tibia near the end so that the lower extremity can be turned forward and upward through an arc of 90°, bringing the scar to the anterior surface of the stump and bringing the muscles down so that they cover the end of the stump.

DISARTICULATION AT THE KNEE-JOINT.—This may be done by the modified circular, the anterior flap, the bilateral flap, or the elliptical method.

Modified Circular.—With the leg extended, make an incision around it, through the skin and fascia, three or four inches below the patella. Split the skin in front and behind and dissect up the flaps until the tendon of the patella is exposed. This is divided, the leg is strongly flexed, and the remaining ligaments are divided, leaving the patella and semilunar cartilages attached to the femur. The tibia is drawn forward, the knife passed behind its upper and posterior border, and the remaining tissues are cut from within outward. Ligate the popliteal artery and branches, resect the popliteal nerve, put in a drainage tube, and unite the flaps vertically.

The Anterior Flap Method.—Make an incision beginning half an inch below the internal condyle of the femur, cutting down the leg, then across and up the outer side to a corresponding point below the external condyle, making a flap equal in length to half the circumference of the knee. Dissect up the flap, divide the ligamentum patellæ and other ligaments of the joint, and cut a short posterior flap from within outward.

The Bilateral Flap Method, or Stephen Smith's Operation.—This is a favorite method of amputation at the knee-joint and is performed as follows: Make two lateral flaps, the inner slightly longer, by entering the point of the knife one inch below the tuberosity of the tibia, cutting downward and forward, then backward and upward to the middle of the popliteal space. The opposite flap is made in the same manner. Dissect up the flaps, divide the ligamentum patellæ, open the joint in front, and disarticulate by cutting from before backward. This makes a "hood" flap, and when healed the scar is on the posterior surface of the thigh.

The Elliptical Method.—Make an elliptical flap a little more than half the circumference of the knee in length, by an incision beginning in the popliteal space about one inch below the joint, carried down-

are exposed, then disarticulate by dividing the ligaments between the astragalus and scaphoid and between the astragalus and os calcis. Be careful not to injure the ankle-joint.

The heel-flap method is performed by making an incision across the under surface of the heel from half an inch below the external malleolus to a point one inch below the internal malleolus. The two ends of this incision are connected by a curved incision across the front of the foot. The flaps are dissected up and the bones disarticulated as in the method of De Lignerolles.

Tripier has modified the operation by sawing through the os calcis horizontally, leaving its upper part attached to the astragalus.

PIROGOFF'S AMPUTATION.—This operation removes all the tarsal bones except the posterior part of the os calcis, also the malleoli

FIG. 29.—Pirogoff's amputation; sawing the os calcis.

and articular surface of the tibia. Make an incision from the tip of the internal malleolus across the instep half an inch in front of the anterior edge of the tibia, to a point on the outer side of the foot half an inch in front of the tip of the external malleolus. Connect the ends of this incision by a cut across the sole of the foot. The heel flap is dissected back for about a quarter of an inch. The ankle-joint is opened in front, the lateral ligaments are divided, and the foot is pulled down until a narrow saw can be applied to the os calcis behind the astragalus and the bone is divided downward and slightly forward. Both malleoli and a thin slice of the tibia are next removed with the saw and the sawed surface of the os calcis is brought up in contact with that of the tibia, to which it is united by means of sutures through the periosteum and other soft tissues. Some advise the use of silver wire to hold the bones in contact. This operation often gives a very serviceable stump, but sometimes necrosis occurs or the bones fail to unite, so that the os calcis must be removed.

Modifications.—Fergusson saws the os calcis only and places it be-

tween the malleoli, and divides the tendo Achillis. Le Fort saws the os calcis horizontally, removing its upper third, and approximates this surface to the sawed surface of the tibia after removal of the malleoli with a thin slice of the tibia. The advantage of this method is the preservation of the normal axis of the os calcis so that pressure is received upon that part of the bone and skin accustomed to it. Hancock saws the os calcis as in Pirogoff's method, and the astragalus horizontally, removing its under surface. He then approximates the sawed surfaces of the astragalus and os calcis.

THE MIKULICZ-VLADIMIROFF OSTEOPLASTIC RESECTION of the os calcis and astragalus is performed as follows: Make a transverse incision across the sole of the foot from the tuberosity of the scaphoid to a point half an inch behind the base of the fifth metatarsal bone. Make an incision from each end of this cut backward and upward to the base of the corresponding malleolus and continue it horizontally around the back of the foot, dividing the tendo Achillis and opening the ankle-joint from behind. The soft parts of the dorsum of the foot are then separated from the astragalus by an elevator and the astragalus and os calcis are disarticulated from the scaphoid and cuboid bones, respectively, the entire heel with the astragalus and os calcis being removed. The articular surfaces of the scaphoid and cuboid are removed with the saw, and the lower ends of the tibia and fibula, with the articular surface of the tibia, are removed in the same way and the sawed surfaces brought in contact and united by sutures,—silver wire through the bones or kangaroo tendon through the periosteum and other soft parts. This operation produces an exaggerated talipes equinus, the patient walking on the ends of the metatarsal bones and the phalanges of the toes.

FIG. 30.—Dissecting out the os calcis in a Syme amputation.

AMPUTATION AT THE ANKLE-JOINT (SYME).—This method removes the entire foot and the malleoli with the articular surface of the tibia. With the foot held at right angles to the leg, make an incision from the tip of the external malleolus with an inclination backward across the sole of the heel to a point opposite the beginning, about half an inch below the tip of the internal malleolus. Dissect up the heel flap, keeping the knife close to the bone until the

tuberosity of the os calcis is passed. Connect the extremities of the first incision by a cut across the instep, opening the ankle-joint in front. Divide the lateral ligaments, complete the disarticulation, divide the tendo Achillis and the other tendons, and remove the foot. Dissect up the soft parts to a sufficient height and saw off the malleoli with the articular surface of the tibia. If there is difficulty in turning the tuberosity of the os calcis in the dissection of the flap, this may be deferred until the ankle-joint has been opened, or the flap may be split on the outer side.

FIG. 31.—Stump after Syme's amputation.

Amputation at the Ankle-Joint (Roux).—In this method a long flap is taken from the inner side and sole of the foot, as follows: Make an incision beginning at the outer border of the tendo Achillis above its insertion, and carry it forward beneath the external malleolus across the instep, one inch in front of the articular edge of the tibia, to a point in front of the internal malleolus. From this point the incision is carried half-way across the sole of the foot, thence back along the heel to the beginning of the incision. Dissect

FIG. 32.—Line of incisions in Roux's amputation of the ankle: *a*, dorsal, *b*, plantar, incision.

up the external flap, open the joint from this side, and complete the internal flap after disarticulation. The malleoli are removed as in Syme's method. If preferred, both flaps may be dissected up before disarticulating the foot.

Whenever it is necessary to amputate above the tarsometatarsal joint, the bones should be divided at the junction of the middle and lower third of the leg, as instrument-makers agree that this gives the best stump for an artificial leg or foot. In every case the patient must be consulted and his decision accepted.

AMPUTATIONS OF THE LEG.—Amputation of the leg may be performed in the lower, middle, or upper third. The methods in use are the *circular, modified circular, elliptical, Teale's,* and *Sédillot's.* The circular or modified circular method and Teale's method are usually preferred in the lower third; in the middle or upper third the elliptical flap method or that of Sédillot is best. The fibula should be divided about half an inch higher than the tibia. The circulation is controlled in amputations of the leg by an elastic tube or strap applied two inches below the head of the fibula or to the middle of the thigh, or the tourniquet is applied to the femoral artery in Scarpa's triangle. The mortality of amputations of the leg varies from 10 to 40 per cent.

The Circular and Modified Circular Methods.—Make an incision around the leg at a distance below the proposed section of the bone equal to one-fourth the circumference of the leg. Dissect up the skin and fascia, with or without slitting up the sides of the cuff. Divide the tendons and muscles down to the bones. Free the bones of soft tissues by passing a knife between them, apply a three-tailed retractor, and saw first the fibula and then the tibia.

Instead of the circular method, oval flaps of skin may be cut, the rest of the operation being the same as in the circular method. Bryant advises covering the end of the tibia with a periosteal flap dissected up with the skin flap from the surface of the tibia below its point of section.

FIG. 33.—Lines of incision in Teale's amputation at the lower third of the leg.

Teale's Method.—In this method a long rectangular flap equal to one-half the circumference of the leg is made from the front and a short posterior flap is made from the back of the leg; or the long flap may be made from the back of the leg. The flaps contain both

FIG. 25a.—Result of railway injury—both legs and one hand crushed. Triple amputation. Patient 72 years old.

flap by carrying the knife downward and outward. Then make an internal flap about one-fourth the length of the external, by cutting from without inward through the skin and muscles.

Bier's Method.—In order to make a stump which will bear pressure well and not be prone to atrophy, Bier makes a second operation after the healing of the wound, in which he removes a wedge-shaped portion of the tibia near the end so that the lower extremity can be turned forward and upward through an arc of 90°, bringing the scar to the anterior surface of the stump and bringing the muscles down so that they cover the end of the stump.

DISARTICULATION AT THE KNEE-JOINT.—This may be done by the modified circular, the anterior flap, the bilateral flap, or the elliptical method.

Modified Circular.—With the leg extended, make an incision around it, through the skin and fascia, three or four inches below the patella. Split the skin in front and behind and dissect up the flaps until the tendon of the patella is exposed. This is divided, the leg is strongly flexed, and the remaining ligaments are divided, leaving the patella and semilunar cartilages attached to the femur. The tibia is drawn forward, the knife passed behind its upper and posterior border, and the remaining tissues are cut from within outward. Ligate the popliteal artery and branches, resect the popliteal nerve, put in a drainage tube, and unite the flaps vertically.

The Anterior Flap Method.—Make an incision beginning half an inch below the internal condyle of the femur, cutting down the leg, then across and up the outer side to a corresponding point below the external condyle, making a flap equal in length to half the circumference of the knee. Dissect up the flap, divide the ligamentum patellæ and other ligaments of the joint, and cut a short posterior flap from within outward.

The Bilateral Flap Method, or Stephen Smith's Operation.—This is a favorite method of amputation at the knee-joint and is performed as follows: Make two lateral flaps, the inner slightly longer, by entering the point of the knife one inch below the tuberosity of the tibia, cutting downward and forward, then backward and upward to the middle of the popliteal space. The opposite flap is made in the same manner. Dissect up the flaps, divide the ligamentum patellæ, open the joint in front, and disarticulate by cutting from before backward. This makes a "hood" flap, and when healed the scar is on the posterior surface of the thigh.

The Elliptical Method.—Make an elliptical flap a little more than half the circumference of the knee in length, by an incision beginning in the popliteal space about one inch below the joint, carried down-

and divide the bone in the usual way. The vessels requiring ligation are the femoral artery and vein, several muscular branches, and, in high amputations, the profunda artery and vein.

The Modified Circular Method.—In this method oval flaps of skin, anteroposterior or lateral, are made by cutting from without inward. The flaps are dissected back and the muscles and bone divided as in the method just described.

The Transfixion Method.—In this method anteroposterior or lateral flaps of skin and muscle are made. To form the *anteroposterior flaps*, enter the point of a long knife in the side of the thigh, carry it to the bone, depress the handle until the point of the knife passes across the bone, then elevate the handle, at the same time pinching up the flesh of the anterior surface of the thigh, and carry the knife through. Carry the knife down parallel with the femur the proper distance before cutting out. Enter the knife behind the bone in the same manner and cut a posterior flap.

DISARTICULATION AT THE HIP-JOINT.—There are various methods of controlling the circulation during amputation at the hip-joint,

FIG. 36.—Result of amputation at hip-joint for sarcoma of knee. Inguinal glands removed.

such as Macewen's method of compressing the aorta by an assistant's fist placed over the vessel slightly to the left of the umbilicus; the use of abdominal tourniquets (Pancoast's and Esmarch's), by which

skin and muscle. The long anterior flap method is performed as follows: Make two lateral incisions, one on either side of the leg, downward, the distance of half the circumference of the limb; connect the lower ends of the incisions by a transverse cut across the front of the leg and dissect up the skin and muscles to where the bone

FIG. 34.—Flaps adjusted.

is to be divided. The posterior flap, about one-fourth the length of the anterior, is made in the same way, including skin and muscles.

FIG. 35.—Section of the leg at its upper third.

The bones are sawed as usual, the arteries ligated, including the anterior and posterior tibial, the peroneal, and muscular branches, a drainage tube is inserted, and the flaps are sutured in position.

Sédillot's Method.—Enter the point of a long knife half an inch external to the crest of the tibia, carry it through the leg to the outer side, grazing the fibula and making the flap as broad as possible by pinching up the flesh on the outside of the leg, and cut a long

FIG. 35a.—Result of railway injury—both legs and one hand crushed. Triple amputation. Patient 72 years old.

flap by carrying the knife downward and outward. Then make an internal flap about one-fourth the length of the external, by cutting from without inward through the skin and muscles.

Bier's Method.—In order to make a stump which will bear pressure well and not be prone to atrophy, Bier makes a second operation after the healing of the wound, in which he removes a wedge-shaped portion of the tibia near the end so that the lower extremity can be turned forward and upward through an arc of 90°, bringing the scar to the anterior surface of the stump and bringing the muscles down so that they cover the end of the stump.

DISARTICULATION AT THE KNEE-JOINT.—This may be done by the modified circular, the anterior flap, the bilateral flap, or the elliptical method.

Modified Circular.—With the leg extended, make an incision around it, through the skin and fascia, three or four inches below the patella. Split the skin in front and behind and dissect up the flaps until the tendon of the patella is exposed. This is divided, the leg is strongly flexed, and the remaining ligaments are divided, leaving the patella and semilunar cartilages attached to the femur. The tibia is drawn forward, the knife passed behind its upper and posterior border, and the remaining tissues are cut from within outward. Ligate the popliteal artery and branches, resect the popliteal nerve, put in a drainage tube, and unite the flaps vertically.

The Anterior Flap Method.—Make an incision beginning half an inch below the internal condyle of the femur, cutting down the leg, then across and up the outer side to a corresponding point below the external condyle, making a flap equal in length to half the circumference of the knee. Dissect up the flap, divide the ligamentum patellæ and other ligaments of the joint, and cut a short posterior flap from within outward.

The Bilateral Flap Method, or Stephen Smith's Operation.—This is a favorite method of amputation at the knee-joint and is performed as follows: Make two lateral flaps, the inner slightly longer, by entering the point of the knife one inch below the tuberosity of the tibia, cutting downward and forward, then backward and upward to the middle of the popliteal space. The opposite flap is made in the same manner. Dissect up the flaps, divide the ligamentum patellæ, open the joint in front, and disarticulate by cutting from before backward. This makes a "hood" flap, and when healed the scar is on the posterior surface of the thigh.

The Elliptical Method.—Make an elliptical flap a little more than half the circumference of the knee in length, by an incision beginning in the popliteal space about one inch below the joint, carried down-

ward and outward across the front of the leg, then upward, inward, and backward to the beginning. The flap is dissected up, the ligamentum patellæ divided, and the joint disarticulated in the usual way. The flap is approximated and sutured with its apex in the popliteal space and the drainage tubes placed in each side where the flap is folded on itself.

Amputation through the knee-joint leaves a good stump for a peg leg, but not so good a one for the use of an artificial leg as an amputation through the thigh about three inches above.

AMPUTATION OF THE THIGH.—Amputation of the thigh may be performed just above the knee by the methods of Gritti and Carden. When performed at a higher point, the circular, modified circular, or flap methods may be used. The circulation is controlled when possible by the elastic strap or tourniquet around the upper third of the thigh; when the amputation is too high for this, by the use of Wyeth's pins and constrictor.

Gritti's Method.—Make a long rectangular flap by an incision from the centre of one condyle of the femur down the side of the leg and across the tibia and up the other side of the leg to the centre of the corresponding condyle. Dissect up the flap, divide the ligamentum patellæ, and dissect up the soft parts until the condyles are exposed, saw them off just above the articular cartilages, and divide the remaining soft parts with a long knife, cutting from within outward. The articular surface of the patella is then removed with the saw and the sawed surface of the patella is brought into contact with the sawed surface of the condyles and held in place with kangaroo tendon through the periosteum, or silver wire passed through small openings drilled through the bones. If preferred, the femur may be divided an inch above the condyles and the articular surface of the patella may be scraped off instead of being sawed.

Carden's Method.—Make a long anterior flap, oval in shape, beginning at the centre of one condyle of the femur and ending at a corresponding point on the other. A short posterior flap is made by cutting from without inward. The flaps are dissected up to the base of the condyles, freed of soft tissues, the patella being removed, and the condyles are sawed through at their base. In persons under twenty years of age only a thin section of the condyles should be removed lest the growth of the femur be arrested.

The Circular Method.—Make a circular incision, dividing the skin and fascia down to the muscles, turn back the flap the proper distance and make another circular incision, dividing the muscles half-way to the bone. As the divided muscles retract, divide the remaining muscles by a third circular incision to the bone. Apply a retractor

and divide the bone in the usual way. The vessels requiring ligation are the femoral artery and vein, several muscular branches, and, in high amputations, the profunda artery and vein.

The Modified Circular Method.—In this method oval flaps of skin, anteroposterior or lateral, are made by cutting from without inward. The flaps are dissected back and the muscles and bone divided as in the method just described.

The Transfixion Method.—In this method anteroposterior or lateral flaps of skin and muscle are made. To form the *anteroposterior flaps*, enter the point of a long knife in the side of the thigh, carry it to the bone, depress the handle until the point of the knife passes across the bone, then elevate the handle, at the same time pinching up the flesh of the anterior surface of the thigh, and carry the knife through. Carry the knife down parallel with the femur the proper distance before cutting out. Enter the knife behind the bone in the same manner and cut a posterior flap.

DISARTICULATION AT THE HIP-JOINT.—There are various methods of controlling the circulation during amputation at the hip-joint,

FIG. 36.—Result of amputation at hip-joint for sarcoma of knee. Inguinal glands removed.

such as Macewen's method of compressing the aorta by an assistant's fist placed over the vessel slightly to the left of the umbilicus; the use of abdominal tourniquets (Pancoast's and Esmarch's), by which

compression is made over the aorta; compression of the aorta by the hand of an assistant introduced into the rectum; compression of the femoral artery as it crosses the brim of the pelvis; or preliminary ligation of the femoral artery. But the best method, when applicable, is that of Wyeth, which is based on the principles of a somewhat similar method devised by Trendelenburg.

Wyeth's bloodless amputation is performed as follows: An Esmarch bandage may be used to squeeze the blood out of the lower extremity. To prevent the tourniquet from slipping use is made of two large needles or skewers, three-sixteenths of an inch in diameter and ten or twelve inches in length. One of the needles is introduced one-fourth of an inch below the anterior superior spine of the ilium, slightly to its inner side, and is made to traverse the skin, fascia, and muscles, emerging on the outer side of the hip, on the same level and about three inches behind its point of entrance. The second needle is inserted half an inch below the crotch, internal to the saphenous opening, carried through the adductor muscles, and its point is made to emerge posteriorly about an inch and a half below the tuberosity of the ischium. Cover the points of the needles with corks. Place a compress, about two inches thick, made of folded gauze or cotton, over the femoral vessels where they cross the brim of the pelvis, and over this and above the skewers wind tightly around the hip five or six times a piece of strong rubber tubing half an inch in diameter, and secure the ends by tying. About six inches below the tourniquet make a circular incision down to the muscles and join this by a longitudinal incision passing from the tourniquet downward over the trochanter major. The cuff of skin and fascia thus made is dissected up to near the level of the trochanter minor, at which point the muscles are divided down to the bone by another circular incision. The principal vessels are secured and ligated at this stage, the muscles are then dissected off, the joint exposed, and disarticulation effected by dividing the capsular ligament and rotating outward and abducting the thigh until the ligamentum teres can be divided. Secure all bleeding vessels, remove the constricting tube, and secure any other vessels which require it. The muscular portions of the stump are approximated by buried catgut sutures and the skin coaptated with silkworm-gut sutures, leaving a rubber tube for drainage.

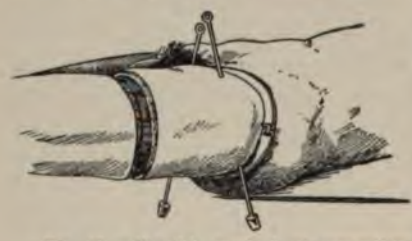


FIG. 37. — Wyeth's method of controlling hemorrhage in amputation at hip-joint. (Wharton and Curtis.)

Furneaux Jordan's method is somewhat similar to the one just described, but the muscles are divided at a much lower point. A straight incision down to the bone is made from a point just above the trochanter major downward along the outer surface of the thigh for five or six inches, or as far as may be necessary. The head, neck, and upper part of the shaft of the femur are freed from their muscular attachments, the joint disarticulated, and the soft parts divided to the bone by a circular incision at the lower end of the longitudinal incision. The vessels are secured and the flaps sutured vertically or transversely.

The Flap Method.—Any variety of flap method may be used,—anteroposterior, lateral, flaps of equal length, or one long and one short flap,—as the exigencies of the case require. The flaps may be made by transfixion or by cutting from without inward. In any case the circulation should be controlled by Wyeth's method.

Liston's method by anteroposterior flaps is performed as follows: Enter the point of a long knife midway between the anterior superior spine of the ilium and the trochanter major and carry it across the front of the hip-joint to emerge in front of the tuber ischii. Cut a long antero-internal flap by carrying the knife downward, then outward, have an assistant retract the flap, open the capsule of the joint, disarticulate, pass the knife behind the head of the bone, and cut a postero-external flap in the same manner, equal in length or shorter than the anterior. Secure the vessels and suture the flaps.

In amputation of the hip-joint the arteries requiring ligation are the femoral, the profunda, the gluteal, the sciatic, the comes nervi ischiadici, and other branches.

Mortality of Hip-Joint Amputation.—Wyeth reports two hundred and sixty-seven cases operated by his "bloodless method," with a mortality of 20 per cent. The mortality in military practice and for traumatisms generally is much greater than it is in civil practice and for disease. Other things being equal, the mortality of amputations of the thigh increases as the body is approached.

CHAPTER VIII.

EXCISION OF BONES AND JOINTS.

THE *excision* of a joint means the partial or complete removal of the cartilages and articular surfaces of the bones composing an articulation.

Arthrectomy or erasion, or atypical excision, means opening the joint and removing, by means of gouge or curette, the diseased parts, such as the synovial membranes, cartilages, and diseased foci on the articular surfaces, without the complete removal of the ends of the bones. It is a more conservative operation than excision, and is especially suited for young patients, as the epiphyseal cartilages are not so apt to be injured with resulting arrest of growth in length of the bones.

Resection is used as a synonym for excision of joints, but by some resection implies the removal of a portion or the whole of the shaft of a bone.

INDICATIONS FOR EXCISION.—The indications for excision are injuries and diseases of bones and joints too severe for conservative treatment and not severe enough to justify amputation. It is often resorted to in the treatment of tuberculous joints, especially the shoulder, knee, and elbow. When the disease is not extensive, *erasion* is preferred to typical excision.

The INSTRUMENTS needed for excision and erasion are the following:

Esmarch's apparatus for providing a bloodless field,
Strong scalpels,
Retractors of different sizes,
Scoops,
Gouges,
Chisels,
A mallet,
Periosteal elevators,
Bone-forceps,
Bone-drills,
Saws, chain or wire and keyhole,
Hæmostats,
Dissecting forceps,
Probe
Ne
N

When ankylosis is desire
ments such as silver wi
needed.

EXCISION OF THE UPPER JAW.—This may be required on account of the presence of malignant tumors. In order to prevent the entrance of blood into the larynx and trachea the patient should be placed in the dorsal position, with his head hanging over the end of a table, the foot of which is raised several inches, and the anæsthetic should not be pushed so far as to prevent coughing. The soft parts may be divided in several ways. Velpeau's incision extends from the angle of the mouth to the centre of the malar bone. Langenbeck's begins on the side of the nose at the junction of the nasal bone with the cartilage, and is carried downward and outward, then upward to the middle of the malar bone, forming a U-shaped flap with the convexity downward. The best incision is that of Fergusson, which begins half an inch below the outer canthus of the eye, and is carried along the margin of the orbit to the furrow between the cheek and the nose, down which it is carried around the wing of the nose to the middle of the lip to its free border. The flap thus made is dissected away from the surface of the bone, and all bleeding vessels are secured as rapidly as possible. One or two incisor teeth are drawn, the soft palate is divided from before backward and transversely behind the palate process of the palate bone, within the mouth, and the palate processes separated by means of bone-forceps or a thin chisel driven from before backward. The nasal process is divided by means of a chain or wire saw introduced through the side of the nose and into the orbit through the lachrymal bone, or by means of bone-forceps, being careful not to injure the eyeball and its attachments. The malar bone is divided near the outer angle of the orbit by a chain saw introduced through the sphenomaxillary fissure in the floor of the orbit near its outer angle and around the malar bone. If desired, the lower margin of the orbit may be left by cutting off the remainder of the bone by means of a sharp chisel (Wyeth). The bone, having been freed from the most of its attachments, is now seized with a pair of lion-jawed forceps and twisted from its articulation with the pterygoid process, bringing the larger portion of the palate bone with it. Secure all bleeding vessels by ligature or packing with iodoform gauze. Carefully unite the edges of the incision, and fill the cavity left by re-

FIG. 38.—Fergusson's incision for excision of the upper jaw.

moval of the bone with gauze. The iodoform gauze may be left in place a week, when it is removed, and healing takes place by granulation. The mortality of the operation is slight, the greatest danger being strangulation from the inhalation of blood. Partial excisions are sometimes made in which the bone is divided through the antrum, removing only the alveolar and palate processes. The deformity following the operation may be corrected by means of a dental plate. Both superior maxillæ may be removed by making Fergusson's incision on both sides.

Excision of the Lower Jaw.—This may be partial or complete. To remove the *entire lower jaw*, make an incision from about an inch and a half below the zygoma downward along the posterior border of the ramus and along the lower border of the jaw to the symphysis, and along the opposite side in the same manner. The facial arteries are ligated and divided and the soft parts peeled off with the periosteum. The bone should be sawed at the symphysis, and each half removed separately by keeping close to the bone and detaching the soft parts by means of the knife and periosteal elevator till the articulation is reached. The most difficult part of the operation is the separation of the temporal muscle from the coronoid process, and the masseter and internal pterygoid from the outer and inner surfaces of the ramus and of the external pterygoid from the neck of the condyle. When the nature of the disease or injury permits, it is best to saw through the ramus or the body of the bone, leaving the articulation and the principal muscular attachments. After removal of the lower jaw, to prevent falling backward of the tongue until adhesions have formed, a strong silk ligature should be passed through the frænum and the end carried outside of the patient's mouth and attached to the dressing. The flaps are united, the cavity stuffed with iodoform gauze, and a dressing and bandage applied.

Fig. 39.—Incision for excision of the lower jaw.

Partial Excision of the Lower Jaw.—Partial excision may include a portion of the alveolar process, or a portion of the ramus or body of the bone. A portion of the alveolar process may be removed through the mouth by means of a mouth-gag, a knife, a periosteal elevator, and bone-cutting forceps or chisels.

Structures to be avoided in excision of the lower jaw are the lingual nerve, the internal maxillary artery, Stenson's duct, and the cervicofacial branch of the facial nerve. The periosteum should be saved if possible, as the attachments of the muscles are preserved and a new bone may be produced.

EXCISION OF THE CLAVICLE.—The clavicle may require removal in whole or in part on account of necrosis or malignant disease. Make an incision along the front of the bone from one end to the other. Detach the soft parts by careful dissection, keeping close to the bone except in malignant disease. The acromial end should be disarticulated first, and then the sternal end. Sometimes it is more convenient to divide the bone in the middle before disarticulating, When the operation is done for *malignant* growth it is often necessary to make one or more vertical incisions to give room. In such cases

FIG. 40.—Result of excision of entire clavicle.

there is apt to be considerable bleeding, and many ligatures, from fifteen to forty, are required. After the removal of the bone and the arrest of hemorrhage, to prevent loss of function, the detached tissues should be united as well as possible across the space left by the clavicle, the trapezius to the deltoid and the sternocleidomastoid to the pectoralis major. The structures to be avoided are the subclavian artery and vein, the innominate vein, the cephalic vein, the branches of the thyroid axis, the brachial plexus, the pleura, and, on the left side, the thoracic duct.

According to Bryant, of seventy-three cases of complete excision there were only six deaths—a mortality of about 8 per cent.

EXCISION OF THE SCAPULA.—The scapula may be excised entire, or the spine, angles, or body may be removed separately.

Excision of the Entire Scapula.—Make an incision along the entire length of the spine of the scapula to the tip of the acromion process. Make a second incision from the middle of the first to the inferior angle of the bone. Other incisions may be made as required. Dissect up the flaps, divide the attachments of the deltoid and trapezius, disarticulate the clavicle and the humerus by dividing the ligaments and tendons around these joints, free the coracoid process, raise the scapula by its inferior angle and divide the remaining muscular attachments, remove the bone, arrest all hemorrhage, and suture the flaps, leaving a drainage tube. Structures to be avoided are the subclavian artery and vein, the brachial plexus, and the subscapular artery. The suprascapular artery must be ligated and divided.

Removal of the Body of the Scapula, leaving the Shoulder-Joint.—Make an incision the entire length of the spine and acromion process. Make a second incision the entire length of the scapula near its vertebral border. Dissect up the flaps and detach the muscles, turn the body of the bone outward, and saw through the bone from the suprascapular notch to the axillary border, leaving the acromion and coracoid processes, the glenoid cavity, and a small portion of the axillary border.

Excision of the Shoulder-Joint.—Resection of the shoulder implies the removal of the articular surfaces of the glenoid cavity and of the upper end of the humerus. Generally, however, only the upper end of the humerus is removed. The *operation* may be done by means of a U-shaped incision, convexity downward, on the anterior and outer side of the humerus, or a longitudinal incision which may be supplemented by a transverse incision outward from its upper end. The longitudinal incision is preferred. Make a straight incision from three to six inches in length from the anterior border of the acromion process downward in the long axis of the humerus. Separate the fibres of the deltoid, expose the capsule, and open it along the outer edge of the long head of the biceps muscle. Retract the edges of the wound and turn the long head of the biceps out of its groove in the humerus, without injury. The muscular attachments to the greater and lesser tuberosities are separated by means of a periosteal elevator when possible; otherwise by means of a knife cutting close

Fig. 41.—Excision of the shoulder-joint. (Wharton and Curtis.)

to the bone. The attachment of the capsular ligament around the neck of the humerus is separated in the same way. The head and neck of the bone are then made to protrude through the incision and as much as is necessary is removed with the chain saw. The glenoid cavity is examined and any diseased part found is removed with forceps, chisel, or gouge. Arrest all hemorrhage, provide for drainage by introducing a tube through the posterior part of the joint, close the incision and apply a suitable dressing, binding the arm to the chest. Passive motion should be practised within two or three weeks, to avoid ankylosis. If the muscular attachments to the periosteum have been preserved, an almost perfect joint is the result.

EXCISION OF THE ELBOW-JOINT.—Excision of the elbow implies the removal of the articular surfaces of the humerus and of the radius and ulna. In some cases erasion is sufficient. Several varieties of incision are used,—the *straight longitudinal*, with or without a transverse incision; the *H-shaped*, consisting of two lateral incisions united in the middle by a transverse one; the *T-shaped*, consisting of one longitudinal incision connected with a transverse one at right angles. The first is preferred.

FIG. 42.—Appearance of the elbow-joint after excision.

Operation.—Make an incision at the back of the joint from two or three inches above the olecranon to a point two or three inches below. The soft parts are separated on either side by means of a periosteal elevator, keeping close to the bone until the condyles of the humerus are turned, being careful not to injure the ulnar nerve, which lies in the space between the olecranon and the internal condyle. Flex the forearm, separate the attachment of the triceps to the olecranon, or, if possible, saw the olecranon and leave the portion to which the triceps is attached. Divide the lateral and anterior ligaments until the condyles of the humerus can be protruded through the wound and sawed off. Examine the upper end of the ulna and if diseased separate the attachments of the brachialis anticus from the coronoid process and remove the articular surface, including the sigmoid cavities. Examine the head of the radius and if necessary remove it, being careful not to injure the attachment of the biceps. Other structures to be avoided, besides the ulnar nerve, are the median nerve and the brachial artery on the anterior surface of the joint. After removing the diseased bone and ligaments, arrest hemorrhage,

insert a drainage tube, and close the wound; put on a dressing, and apply an internal angular splint with the arm flexed at a right angle. Begin passive motion in two or three weeks. A useful joint results, especially if the muscular attachments have been preserved.

Excision of the Wrist.—Excision of the wrist means the removal of the articular ends of the radius and ulna and of one or both rows of the carpus, or so much of them as may require it. The joint is opened on the *dorsal* surface in order to avoid the important vessels and nerves on the anterior surface. One or two longitudinal incisions are necessary. Make an incision from the middle of the ulnar border of the second metacarpal bone upward for about four inches. The incision is carried down to the bones, being careful not to injure the tendons, which are drawn to either side with retractors. The opening is made between the extensor indicis on the one side

Fig. 43.—Splint applied after excision of wrist.

and the extensor longus pollicis and the extensor carpi radialis brevior on the other. The hand is strongly flexed, causing the first row of carpal bones to project. As many of these as may be diseased are removed, and resection may be carried further, even including the bases of the metacarpal bones if necessary. The ends of the radius and ulna are then freed and sawed off. After the arrest of hemorrhage, drainage is provided, the wound closed, and the hand and forearm placed on a well-padded splint. Passive motion should begin early, as ankylosis is apt to occur.

Excision of the wrist is not a satisfactory operation, on account of the ankylosis of joints and tendons which so commonly occurs.

Excision of a Metacarpophalangeal Joint.—Make an incision on the dorsal surface of the joint from one to two inches in length, separate the soft parts, push the extensor tendon to one side, divide the lateral ligaments, and remove the ends of the bones with a saw or bone-forceps.

Excision of the Hip-Joint.—Excision of the hip-joint implies the removal of the head of the femur and of so much of the acetabulum as may be involved. The operation is required for tuberculosis, gunshot or other severe injury, and for ankylosis with the limb in bad position.

Operation.—Place the patient on the sound side with the thigh of the diseased side flexed nearly at a right angle with the body. Make a *straight* incision six to eight inches in length, beginning three or four inches above the trochanter, passing over the trochanter in the long axis of the femur and in line with the posterior superior spinous process of the ilium. Separate the fibres of the gluteus maximus. Detach the muscular insertions into the trochanters by raising the periosteum or chiselling off the fragments of bone which contain the insertions. Open the capsular ligament, rotate the thigh outward, and adduct it until the head of the bone is sufficiently displaced to permit of division of the ligamentum teres, after which the head is made to protrude until a chain or wire saw can be passed around it and the head removed. If the disease includes the trochanter this should be removed with the head and neck of the bone. The acetabulum is carefully examined and any diseased part removed with gouge or chisel. Drainage is provided and if the acetabulum has been perforated the drainage tube should extend through the perforation. The wound is closed and the patient put to bed, with sand-bags placed by the side of the limb in order to keep it steady. In some cases it is advisable to apply a Buck's extension. After the wound has healed, motion should be encouraged in order to get a movable joint. The patient should be got out of bed as soon as possible and may wear a Thomas splint.

Anterior Method.—Some surgeons prefer to expose the joint by an anterior incision, on the ground that less damage is done to the muscles. Make an incision on the front of the joint from half an inch below the anterior superior spine of the ilium, four or five inches downward and slightly inward until the tensor vaginæ femoris and gluteal muscles are exposed and drawn to the outer side. The sartorius and rectus are drawn to the inner side. This exposes the capsule, which should be opened, the head of the bone dislocated and treated as may be necessary. The mortality of excision of the hip-joint for disease is slight—according to Wright only 3 to 5 per cent. The most favorable age is from five to ten years. The mortality when performed on account of injury is much greater.

EXCISION OF THE KNEE-JOINT.—A variety of incisions is used,—the *semilunar* or *horseshoe-shaped*, with the convexity downward or upward; a *transverse incision*, with or without sawing the patella in two; or a *longitudinal incision* in front or on the side. The method preferred is the semilunar or horseshoe-shaped with the convexity below.

Operation.—With the knee flexed to a right angle, make an incision from the upper part of the internal condyle across the front of

the knee below the patella to a corresponding point on the outer side of the knee. The ligamentum patellæ is divided, also the crucial and lateral ligaments, and the end of the femur is exposed and a thin slice of the condyles removed, if possible not extending above the epiphyseal line. The end of the tibia is exposed and a thin slice removed in the same way, the object being to obtain ankylosis. The sawed surfaces are then approximated and held in place by nails or ivory pegs driven obliquely from one bone to the other, the heads projecting above the skin so that they may be removed when no longer needed. Heavy silver wire may be used, or the use of splints alone may be depended on. After arrest of hemorrhage the wound is closed without drainage and a plaster-of-Paris cast applied from the foot to the middle of the thigh. The patella may be removed or left in place. König recommends sawing off the posterior surface of the patella and nailing the remainder of the bone to the anterior surfaces of the femur and tibia. In removing the articular surfaces care must be taken to avoid injury of the popliteal vessels. This is done by sawing from behind forward.

Excision of the Ankle-Joint.—*Lauenstein's Method.*—Make an incision, beginning about two inches above the external malleolus, carry it along the posterior border of the fibula below its extremity and then forward to the dorsum of the foot about the astragaloscaphoid articulation. The skin is dissected up, the peroneal tendons detached with the periosteum downward, the external lateral ligament divided, and the external malleolus sawed off. The anterior and posterior ligaments are then divided and the tendons retracted in front and behind until the foot can be dislocated and the articular surfaces of the tibia and astragalus exposed and removed by the saw or chisel. The foot is then replaced, drainage provided, the wound closed, and a plaster-of-Paris cast applied. The operation may be performed by two lateral incisions, both curved forward and extending along the internal and external malleoli respectively. Many useful joints result from this operation, but often ankylosis occurs, or prolonged suppuration may eventually require amputation.

Excision of the Os Calcis.—Make a horseshoe-shaped incision from the calcaneocuboid articulation around the back of the foot just above the sole of the heel to a corresponding point on the inner side. Make a second incision about two inches in length down the middle of the tendo Achillis to the first one. The flaps are dissected off, the articulation between the os calcis and the astragalus opened, the ligaments between the os calcis and the cuboid severed, and the bone removed. The deformity after resection of the os calcis is great, but a useful foot results.

EXCISION OF THE ASTRAGALUS.—The astragalus may be removed by an oval incision extending between the malleoli on the dorsum of the foot with the convexity downward, turning up a flap of skin and separating the tendons, or by an *internal* or *external* incision along the respective malleoli.

The External Incision.—Make an incision along the posterior border of the fibula below the malleolus nearly to the astragalo-scaphoid articulation, as in excision of the ankle-joint. Divide the external lateral ligaments, draw aside the tendons, and invert the foot until the astragalus can be seized with bone-forceps and the ligamentous attachments to the scaphoid and os calcis severed. The foot is then replaced and the wound closed with or without drainage and fixed in a plaster cast. The functional result is usually good.

The Internal Incision.—Make a curved incision from the tip of the internal malleolus, forward, upward, and outward, open the ankle-joint, draw the tendon of the tibialis anticus forward, and, by strong eversion of the foot, expose the astragalus, so that it can be seized with lion-jawed forceps and removed after separating its ligamentous attachments.

EXCISION OF A TARSOMETATARSAL JOINT.—This may be done through a straight incision or by raising a semilunar flap from the dorsal surface. Draw aside the extensor tendon and remove the bone by means of a saw, bone-forceps, or chisel.

EXCISION OF A METATARSOPHALANGEAL JOINT may be done by the same kind of incisions as in the preceding.

CHAPTER IX.

PLASTIC SURGERY.

PLASTIC SURGERY has for its object the moulding or shaping of an organ or tissue into proper shape, the repair of defects, congenital or acquired, and the correction of certain deformities. Such operations may be done in order to restore function, as in harelip and cleft palate, exstrophy of the bladder, cicatricial contractions, extensive ulceration; or for cosmetic effects, as in malformation of the nose, ears, lips, tongue, etc.

While bone, bone chips, muscle, nerve, periosteum, and tendon have all been used in plastic operations, the tissue most frequently employed is the *skin*. Most of these operations are described in other parts of this work, and it remains only to consider the methods by which defects in the skin and bone are treated.

When the tissues used in repair are derived from the patient, the term *autoplasty* is used, and when they are obtained from some other source the procedure is called *heteroplasty*.

TIME FOR OPERATION.—In making repairs for defects resulting from disease the operation should not be performed until the disease has been arrested and a healthy surface obtained. Success depends largely on the maintenance of strict asepsis, so that, as a rule, it is useless to operate as long as suppuration is going on.

METHODS IN USE.—In closing gaps in the skin, the tissues in the immediate vicinity may be used by freshening the edges, dissecting them loose, and sliding them over, making various incisions to facilitate approximation according to the requirements of the case, and leaving the new wounds caused by the incisions and left by the sliding of the flaps to heal by granulation. The skin may be obtained a short distance away from the wound in the form of a flap with a pedicle which is twisted upon itself, but not enough to interfere with circulation, until the flap can be fitted to its new position. After union has taken place the pedicle is divided. The flap should always be one-fourth to one-third larger than the space it is intended to cover, to allow for shrinking.

SKIN-GRAFTING.—*Reverdin's Method.*—Reverdin's method consists in transplanting a number of small grafts composed of the epidermis to the granulating surface. The grafts should be small, about the eighth or twelfth of an inch in diameter, and may be obtained

from the patient himself, from a friend, or from a recently amputated limb, by cutting with a razor or with scissors curved on the flat. In performing the operation the ulcerated surface should first be prepared by cleansing it of discharges by irrigation with salt solution and then drying it by gentle pressure with sterile gauze. Strong antiseptics should not be used, as they may injure the granulations and prevent their taking hold of the grafts. The area from which the grafts are to be taken is thoroughly disinfected, the grafts cut and immediately placed, cut surface down, upon the granulations. The grafts should be placed on the surface in regular order as near to one another as the number which can be obtained will permit. The surface is then dressed with sterile gauze wrung out of salt solution, held in place by a bandage, and this should be kept moist with salt solution, and should not be removed for a week. At the first examination many of the grafts will have disappeared, but at a later dressing they will be seen as bluish-white spots, showing commencing growth of the epidermis. These increase in size, and gradually merge with one another and the borders of the skin until the entire surface is covered with epidermis. In changing the dressing care must be taken to have it thoroughly wet, to prevent removal of the grafts. The surface from which the grafts have been cut should be dressed aseptically.

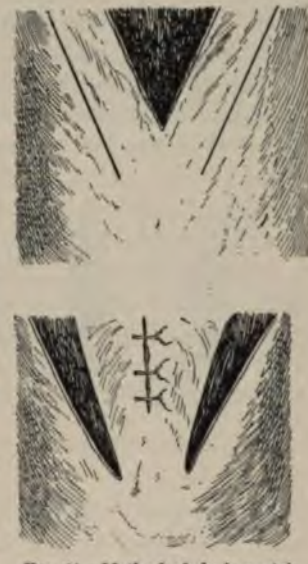


FIG. 44.—Method of closing a triangular gap.

Thiersch's Method.—In this method long strips of skin, consisting of the epidermis and papillary layers, are cut from the patient, from a friend, or from a recently amputated limb and applied to the granulating surface. The parts are prepared as in Reverdin's method. If the granulations are flabby and indolent, the surface is curetted; otherwise the strips of skin are applied directly to the granulations. The strip is cut from the arm or thigh by a sawing motion of the razor, while the skin just in front of the instrument is kept tense by the thumb and finger of the surgeon placed on either side of the limb and carried downward in advance of the instrument. Strips an inch or more in width and from six to twelve inches in length may be removed in this way and immediately applied to the granulating surface until it is covered. A piece of rubber tissue or an ordinary

sterile gauze dressing is then applied, and kept in place for a week before changing. This method is superior to Reverdin's, as the parts heal quicker, the new skin is less apt to break down, and cicatricial contraction is not so likely to follow.

Krause's Method.—This consists in the transplantation of one or more skin flaps, consisting of the *entire thickness* of the skin, to the defect after all diseased or ulcerated tissues have been dissected away. The flaps are held in place by a few interrupted sutures and a sterile dressing applied. The wounds left by removal of the flaps may be partially closed by sutures, dressed, and allowed to heal by granulation. Mucous membrane may be transplanted in the same way, but is less apt to succeed on account of the difficulty in main-

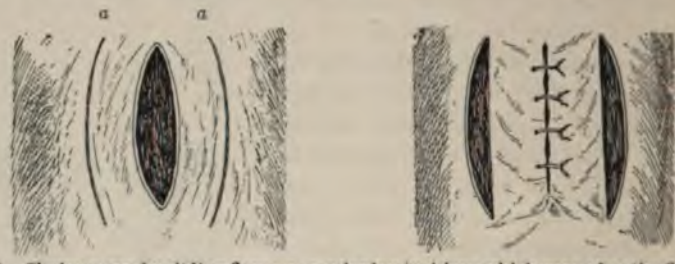


FIG. 45.—Closing a gap by sliding flaps: *a*, *a*, relaxing incisions which gape after the flaps are brought together.

taining asepsis. Defects in the conjunctiva, urethra, and mouth have been made good by the transplantation of mucous membrane taken from animals.

In suitable cases, as after extensive loss of skin from the hand or forearm, the following method of autoplasty is sometimes used: Dissect up from the abdominal wall a loop or flap of skin of sufficient size, leaving it attached at one or both ends. Thrust the hand or forearm beneath this loop or flap, attach it to the wound with sutures, and bind the hand or forearm in this position. After union has occurred, perhaps in from ten to fourteen days, sever the flap from the body and close the wound caused by its removal by sliding skin flaps, or leave it to heal by granulation.

BONE-GRAFTING.—The button of bone removed in the operation of trephining the skull is sometimes replaced and may unite, but is more apt to undergo necrosis. An osteoplastic flap made by cutting through the soft tissues and bone, without separating one from the other, is sometimes made in opening the skull or in operations on other parts of the body, and when returned to its place is usually followed by union.

Senn's Method.—Senn's method consists in the use of chips of

decalcified bone for the filling up of cavities left in the bones after disease or operations. The bone chips are prepared from the fresh bones of an ox (tibia or femur) by removing the periosteum and medulla, sawing the bone into pieces of from one-half to one inch in length, then soaking them for three weeks in a 15 per cent. solution of hydrochloric acid which is changed daily. The fragments of bone are removed from the acid, throughly washed in water, cut into thin plates or strips, washed in a weak solution of caustic potash, and placed for forty-eight hours in a 1 to 1000 solution of bichloride of mercury. They should be kept in a 1 to 500 solution of bichloride in alcohol, or in a saturated solution of iodoform in ether. Before using they are soaked in a 1 to 2000 solution of bichloride in water, or in sterile water. The bone cavity—for example, the tibia—is thoroughly cleansed, scraped out and freed from all disease, rendered aseptic, and loosely packed with the bone chips. The soft parts are closed over the chips, or if this is impossible an iodoform dressing is applied. The bone grafts act as a scaffolding which becomes infiltrated with bone-forming cells, after which the grafts are absorbed. Plates of bone prepared in the same way are sometimes used to close defects in the skull, proper provision being made by means of perforations for the escape of secretions.

CHAPTER X.

MINOR SURGERY.

COUNTERIRRITATION.—This consists in the production of local irritation of the skin in order to relieve inflammation or other morbid processes more deeply situated. For this purpose the following remedies are used.

Hot Water.—This may be applied in the form of wet or dry heat, by using cotton or flannel cloths wrung out of the water, or a rubber bag filled with water and applied to the part until the skin becomes red.

Spirit of Turpentine.—This may be applied in the form of the *turpentine stupe*, made by wringing flannel cloth out of hot water, sprinkling it with turpentine, and then applying it to the patient's body and covering with a dry cloth or piece of oiled silk. If a more vigorous action is desired, the turpentine may be rubbed on the body or the cloth may be wrung out of turpentine and applied. Aqua ammoniæ, chloroform, capsicum, and mustard may be used for the same purpose, but it should be borne in mind that all of these remedies will produce vesication if kept on too long.

Blisters or Vesicants.—When a higher and more lasting degree of counterirritation is desired, blisters are produced. For this purpose some preparation of the Spanish fly is most commonly used, either the *ceratum cantharidis* in the form of a plaster or *cantharidal collodion* painted on the surface. As above stated, all the rubefacients will produce vesication if kept on long enough.

The Actual Cautery.—The actual cautery is a metallic instrument, usually iron or platinum, heated to a red or white heat in an ordinary fire, in an alcohol flame, or by electricity. It is used as a counter-irritant by drawing parallel lines or stripes over the affected part, for the destruction of morbid growths, for the arrest of hemorrhage, and for dividing the more vascular tissues, as the lung.

Paquelin's *thermocautery* is one of the most convenient forms of the actual cautery. It consists of a hollow platinum-sponge instrument, which may be of various shapes, to which is attached a handle covered with wood. The instrument is connected by a rubber tube to a receptacle containing benzine or rhigolene, to which is also attached another rubber tube with a couple of bulbs like a hand

spray apparatus. The instrument is worked as follows: Fill the receptacle about half full of benzine and see that the air can be pumped through the tubes and the instrument. The point of the platinum instrument is then heated to redness in the flame of an alcohol lamp, after which it can be kept at this stage by squeezing the bulb, or made white hot, depending on the rapidity with which the bulb is squeezed; the current of air carried through the tube and the upper part of the benzine receptacle carries the benzine vapor to the already heated platinum instrument, to which it acts as fuel to keep up the temperature.

The Galvanocautery.—This is another form of the actual cautery, in which the platinum instrument, which may be made of any shape, is connected with the electrodes of a galvanic battery, the strength of the current regulating the degree of heat which is obtained.

Hypodermatic Injections.—These are made with syringes composed of metal, with a piston-rod which should be composed of the same material, so that the entire instrument may be sterilized, and fine hollow needles made of gold, platinum, or steel. In using the instrument it should first be sterilized by boiling or dipping it in boiling water. The medicine to be used is dissolved in sterile water in a sterilized spoon or other suitable receptacle, and is drawn into the syringe; or water, fifteen to thirty minims, is drawn into the syringe, the pellet dropped in, the needle screwed on, and the syringe shaken until the pellet is dissolved. The instrument is held with the point up, the air rises to the top and is expelled by forcing the piston-rod upward until a few drops of fluid escape from the point of the needle. The portion of the body into which the injection is to be made should be sterilized by washing with soap and bichloride. The skin is pinched up between the thumb and finger and the needle quickly inserted its full length obliquely through the skin into the subcutaneous cellular tissue. The fluid is then slowly injected as the needle is gradually withdrawn, the puncture being compressed for a short time with the finger after the needle is removed. When the pain is localized, the injection should be made into the region affected; otherwise the outer aspect of the arm or the anterior surface of the thigh may be chosen, taking care not to puncture a vein or artery. After use, the instrument should be cleansed, the needle dried by the use of hot water and the passage of a fine wire through it, and put away, the wire remaining in the needle.

Aspiration.—Aspiration is used in order to remove fluids from a closed cavity without the admission of air, or for exploratory puncture. The instrument most frequently used is that of Potain, which consists of hollow needles and trocars and cannulæ of different

sizes, which can be attached to a rubber tube, the other end of which is connected with a large bottle fitted with a rubber stopper provided with two stopcock tubes. The other branch of the tube in the rubber stopper is connected by means of a rubber tube with a pump for exhausting the air from the bottle.

Operation.—Place the rubber stopper in the bottle and attach the pump by means of the rubber tube to one of the branches. Turn the cock on the needle side so as to close the tube, and open that on the side next to the pump. Exhaust the air in the bottle and turn the stopcock, cutting off external communication, attach the tube containing the needle or cannula, and insert the needle, which has, of course, been sterilized, into the tissues. Then turn the cock making communication between the needle and the vacuum in the bottle. The fluid runs through the needle and the tube into the exhausted bottle. After the completion of the operation, withdraw the needle and seal the puncture with collodion, or a little sterile gauze held in place with adhesive plaster. Before using the instrument test it by exhausting the bottle and inserting the needle into a basin of sterile water.

VENOUS INFUSION AND HYPODERMOCLYSIS WITH PHYSIOLOGICAL SALT SOLUTION.—The salt solution is prepared as follows:

Take of Sodium chloride ..... 6 grammes (1½ drachms);
Bicarbonate of sodium ..... 1 gramme (15 grains);
Distilled water..... 1000 grammes (2 pints).

This solution, when used, should have a temperature of about 100° F. The instrument for introducing it consists of a fountain syringe, or of a glass bottle with an opening near the bottom, to which is attached a long rubber tube with a good-sized hollow needle or small cannula at the other end. The entire apparatus and the salt solution must be carefully sterilized. The vein, preferably the median cephalic or median basilic, is made prominent by placing a bandage firmly around the arm above the elbow. It is next exposed and isolated by passing a probe or grooved director beneath it. The fluid is then allowed to run through the needle from the reservoir, and while so running, the needle is inserted into the vein in the direction of the blood-current, and as much of the fluid is injected as is thought necessary, usually from half a pint (250 c.c.) to a quart (1000 c.c.). The solution should be injected slowly, but the process may be hastened by raising the reservoir to a height of three or four feet above the patient. When a blunt-pointed cannula is used, the vein is opened by a small incision, into which the cannula is introduced and secured by tying a ligature around it and the vein. On the

completion of the operation of infusion the needle or cannula is withdrawn, the incision in the skin closed with one or more sutures, and a compress kept in place with a bandage is applied tight enough to arrest bleeding from the vein.

Hypodermoclysis is the injection of the saline solution into the subcutaneous cellular tissue, usually of the breast or abdomen. For this purpose the same apparatus as that provided for venous infusion is used. Injection of salt solution into the *arteries* has been used, but is not to be recommended.

BLOODLETTING. — Bloodletting may be *local* or *general*. Local bloodletting is effected by *scarification*, *cupping*, or *leeching*.

Scarification consists in making numerous small incisions or punctures in the skin or mucous membrane with the point of a sharp knife or an instrument with numerous blades called a *scarificator*. The flow of blood may be increased by the application of warm aseptic fomentations. *Cupping* is done by means of cupping-glasses provided with a suction pump, or in the absence of this a small tumbler or wine-glass may be used. The glass is applied by moistening the interior with a little alcohol, lighting it, and at once applying the glass firmly over the part; or a twisted piece of paper may be lighted, placed in the glass, and the latter immediately applied. As the heated air cools it contracts, diminishing the pressure over the part included in the glass, which is thus sucked in. The cup is removed by pressing down the skin on one side, or it may be allowed to remain until it drops off. This is *dry cupping*. *Wet cupping* means the withdrawal of blood by means of the cup. The surface is first scarified by means of a lancet or a spring scarificator, and the cups applied, and when filled with blood, or when they cease to draw, are removed, cleansed, and reapplied. Another method is to apply the cup first and, after it has drawn, scarify, and reapply the cup. After completing the operation the wounds are dressed aseptically.

Leeching.—By means of a leech from one drachm to half an ounce of blood may be drawn. Several leeches may be applied at the same time. There are two varieties of leech,—the American, which can draw about one drachm of blood, and the Swedish, which can draw three or four times as much. The leech is applied as follows: Disinfect the skin and then put a few drops of milk or blood on the surface to which the leech is to be applied. The leech should be placed in fresh water for a few minutes and dried by gently touching with a soft warm cloth. It is then placed in a test-tube or small glass, which is inverted over the skin and held in place until the leech attaches itself. Leeches should not be applied over loose cellular tissue, as the eyelid, scrotum, or penis. Never pull a leech,

and if it does not drop off after a reasonable time, sprinkle a little salt upon it. Persistent oozing may be arrested by a compress.

Venesection or Phlebotomy.—In this operation a vein is opened and the blood removed from the general circulation. The vein usually selected for this purpose is the *median basilic* or the *median cephalic.* When an immediate effect on the brain is desired the *external jugular* is sometimes chosen. The operation at the elbow is performed as follows: Apply a bandage about the middle of the arm, tight enough to retard the venous circulation without interfering with the radial pulse. This causes the veins to swell and become prominent. Disinfect the skin and make an oblique incision over the median cephalic or median basilic until the vein is exposed. In opening the median basilic vein avoid the internal cutaneous nerve and brachial artery, the former lying in front of, and the latter behind, the vessel. Let the blood flow until enough has escaped to produce the desired effect, usually from eight to twenty ounces, then remove the bandage, suture the skin, and apply a light compress and bandage.

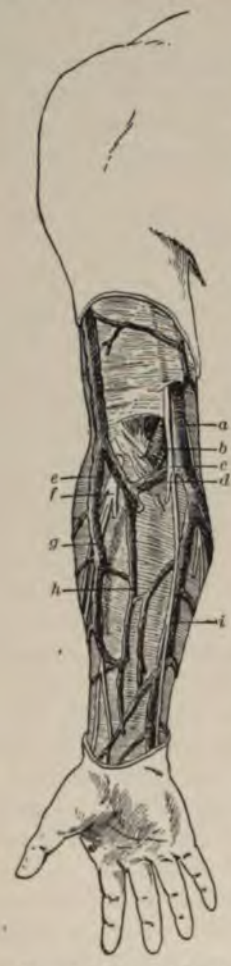


FIG. 46.—Superficial veins of the upper extremity: *a*, basilic vein; *b*, brachial artery; *c*, internal cutaneous nerve; *d*, median basilic vein; *e*, median cephalic vein; *f*, external cutaneous nerve; *g*, radial vein; *h*, median vein; *i*, anterior ulnar vein. (After Gray.)

VACCINATION.—Vaccination is best performed by using bovine virus, glycerinated, on ivory points or in tubes, although lymph taken from a vesicle on a healthy infant on the eighth or ninth day may be used.

Operation.—Disinfect the skin, preferably on the outer side of the arm at the insertion of the deltoid, or on the leg just below the knee. If the ivory point is used, render the skin tense by pressure of the thumb and finger on each side, and scratch the cuticle away by means of the ivory point upon which the virus is dried, until a surface about one-eighth of an inch square is exposed. Two such wounds should be made; the ivory point is then moistened with sterile water and rubbed into the abraded surfaces. If preferred the operation may be performed with a lancet. For rapid vaccination a needle having a spear-point is used, dipped

into the virus and inserted two or three times beneath the cuticle. After vaccination the wounds should be permitted to dry before applying a dressing. This may consist of sterile gauze or cotton held in place by adhesive plaster, or of a perforated shield made of celluloid or other material. Care should be taken to change the dressing frequently in case of discharge from the sore.

METHODS OF SUTURING AND KNOTTING.—Sutures may be *exposed* or *buried*. *Exposed sutures* are those which penetrate all the layers of the skin. *Buried sutures* may be *deep* or *subcuticular*. The deeply buried suture is usually composed of kangaroo tendon, catgut, or silk. The *subcuticular suture* may be composed of any suture material, as it may be left for absorption or be removed after healing. It is introduced as follows: The suture is passed through the skin into the angle of the wound. The needle is then introduced on the under surface of the skin on one side, brought out just beneath the cut edge, entered in the reverse direction on the opposite side, and so on, making a continuous suture which includes only the cuticle, after the completion of which the skin is penetrated from within outward and the two ends of the suture projecting through the skin at each end of the wound may be tied together for safety. The needle is carried through the subcuticular structures without coming in contact with the epidermis, except at the point of entrance and at the completion of the operation, so there is less danger of infection by the skin coccus. If non-absorbable material is used, after union the suture can be easily withdrawn by cutting off one end and pulling on the other.

The Continuous or Glover's Suture.—Pass the needle from without in on one side of the wound and from within out on the opposite side and secure the suture by tying. The needle is again inserted on the side first penetrated and brought out upon the opposite side, and so on until the wound is closed. The last suture is secured by tying the loop on one side and the single terminal thread on the other across the wound.

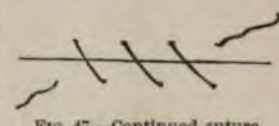


FIG. 47.—Continued suture.

The Interrupted Suture.—This is introduced in the same manner as the *continuous suture*, but the knot is tied and the ends cut off each time the needle is passed through the edges of the wound. It is more suitable than the continuous suture for bringing together the deeper parts of a wound,—for example, in closing the abdominal incision after laparotomy.

The Quill and Plate Suture.—A needle armed with a double thread is passed through the tissues, usually some distance from the edges of the wound, and a quill, roll of gauze, rubber tube, or other suit-

able material, is inserted into the loop on one side, while on the other side the needle is cut away and the two threads secured in like manner around another quill. This is repeated until the wound is closed. Buttons or pieces of lead may be used for the same purpose. This suture is suitable for securing accurate apposition of the deep portions of a wound when for any reason buried sutures are not used.

FIG. 48.—Quilt or mattress suture.

The Harelip Suture. — Thrust a needle or pin through the edges of the wound so as to bring them into accurate approximation. Then apply a thread of silk by a figure-of-8 turn around the ends of the needle and across the wound. The ends of the pin or needle are then cut off, in order to prevent them from injuring the skin.

The Shotted Suture.—In this suture instead of tying a knot the ends are secured by means of perforated shot. It is convenient in closing wounds in the mouth, rectum, or vagina.

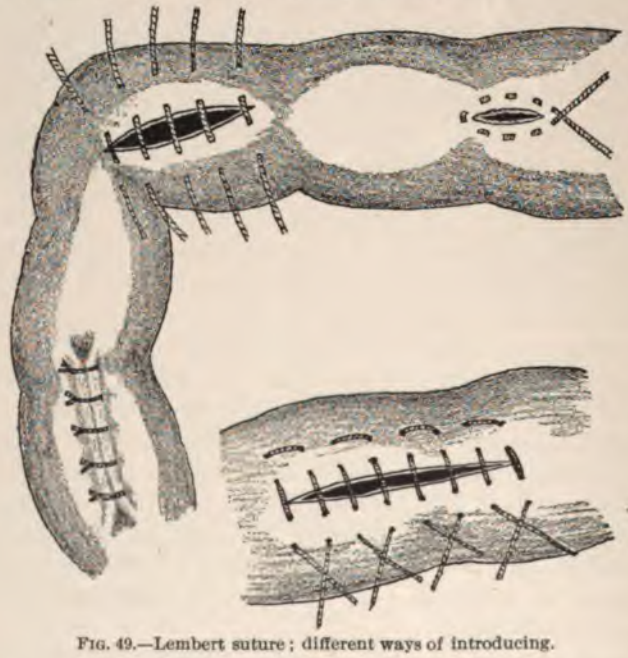


FIG. 49.—Lembert suture; different ways of introducing.

The Czerny-Lembert Suture.—This is a combination of two sutures, —namely, that of Czerny and that of Lembert. It is often used to

close wounds in or to unite the ends of an intestine. The first row of sutures passes through all the coats (the Czerny suture) and the second row is introduced outside of the preceding, and includes all the coats of the intestine, except the mucous, bringing the peritoneal surfaces together and inverting the first row (the Lembert suture). The sutures should be placed about the sixth of an inch apart, and may be continuous, interrupted, mattress, or any modification. A cambric needle with fine silk is selected for the work.

In securing ligatures and sutures three kinds of knots are in use, —namely, the *reef* or *flat knot*, the *surgeon's knot*, and the *common* or *granny's knot*.

The Reef or Flat Knot.—Pass one end of the suture or ligature over and around the other end, drawing it as tight as may be necessary; then carry the same end again over and around the other end in the same direction, and draw the knot tight. The point is to carry

FIG. 50.—Reef knot.

FIG. 51.—Surgeon's knot, first loop.

the same end of thread both times over and around the opposite end in the same direction. This is an excellent knot, and when complete is less likely to slip than any other.

The Surgeon's Knot.—Carry one end of the thread twice around the other end, tighten the loop, and carry the same end once over and around the other, as in the reef knot. This method has the advantage of preventing slipping or relaxation of the first loop while the second is being made. It is especially useful in tying animal sutures or ligatures, in which it is always best to make still a third loop, on account of the probability of the ends slipping and the knot becoming untied.

The Ordinary or Granny's Knot.—The first loop is made as in the reef knot by carrying one end of the thread over and around the other. The second loop is made by carrying the same end of the thread over and around the other end in the opposite direction from the first loop. This knot is more apt to slip than either the reef or the surgeon's knot.

Metallic sutures are secured by twisting the ends or by clamping them with perforated shot.

CHAPTER XI.

BANDAGING.

Bandages are strips of cloth which are wound about various parts of the body for the purpose of holding dressings in place, producing compression, or maintaining immobility. The materials used for bandages include cotton cloth, cheese cloth, gauze, flannel, and rubber, and these (except the rubber) may be impregnated with plaster of Paris, starch, or silicate of sodium, in order to give rigidity to the bandage when it is desired to use it as a splint. Bandages vary in length from one yard to ten or twelve yards, and in width from one to four inches. In making a bandage it is important that the edges

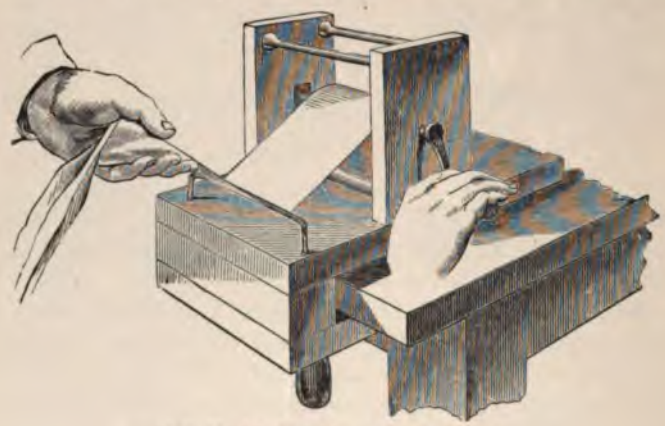


FIG. 52.—Machine for rolling bandages.

should be free from selvages, ravellings, and seams. Before applying the bandage it should be made into a tight roll, either by a machine or by the hands. To make a roll by hand, fold one end of the strip several times to make a small cylinder. Grasp this by the extremities with the thumb and middle finger of the left hand while the strip next to the cylinder is grasped between the thumb and index-finger of the right hand. Now by alternate pronation and supination of the right hand the cylinder is revolved and the roll formed.

RULES FOR BANDAGING.—In applying a bandage to an extremity always include the hand or foot and never allow the proximal portion

of the bandage around an extremity to be tighter than the peripheral portion. In applying a bandage the operator takes the roll in his right hand and applies the external surface of the free extremity to the part, passing it around two or three times in order to fix it, and then proceeds. It should be applied smoothly, firmly, but not too tightly, avoiding as far as possible wrinkles and creases, and each succeeding turn should cover from one-half to two-thirds of the preceding turn. When applied to parts which are cylindrical or uniform in diameter, the circular method may be used, as in the chest or arm. In applying the bandage to parts having a conical shape, flexures or projecting points, or at the junction of the extremities with the body, as in the arm, leg, ankle, knee, shoulder, and hip, the *figure-of-8* or *spica* bandage is best, although in conical limbs the *spiral reversed* bandage is sometimes used, but is not so apt to remain in place as the figure-of-8.

FIG. 53.—Forming a roller bandage by the hands.

FIG. 54.—Making the spiral reverse.

VARIETIES OF BANDAGE.—Besides the *roll bandage* consisting of a single strip of cloth, there are various forms, such as the *single T-bandage*, which consists of a horizontal band to which is attached, about its middle, another bandage which should be at least six or eight inches in width. This is used to retain dressings or instruments

in the region of the perineum. The *double T-bandage* has two vertical strips instead of one attached to the horizontal strip. The *four-tailed bandage* is made by splitting both ends of a wide bandage,

FIG. 55.—T-bandage.

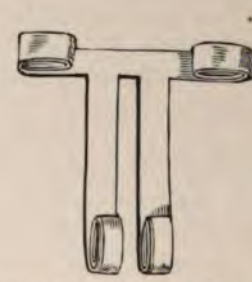


FIG. 56.—Double T-bandage.

and is used in treating injuries of the lower jaw, the broad part of the bandage being applied to the chin while two of the tails are carried to the vertex of the head and secured by knotting or pinning, the other two being carried to the back of the neck and secured in like manner. The *many-tailed bandage* consists of a broad piece of cloth, from twelve to twenty-four inches in width, each end of which is torn into as many tails as may be desired. This bandage is often used to retain dressings on the abdomen after laparotomy. It is applied by placing the body of the bandage under the patient's back while the tails are brought around in front and lapped over one another, making firm and equable pressure. *Handkerchief* bandages consist of square or oblong pieces of cloth arranged in various shapes according to the part to which they are to be applied. They are convenient for application to the lower jaw, the shoulder, and the hip.

FIG. 57.—Recurrent bandage of the head.

SPECIAL METHODS OF BANDAGING. — *Recurrent Bandage of the Head.*—Place the end of an inch and a half or two inch bandage on

the forehead or the occiput and make two circular turns around the head just above the ears. Then carry the bandage along the vertex from the forehead to the occiput and from the occiput to the forehead, an assistant holding the ends, each turn overlapping the preceding one-half or two-thirds until the entire scalp, or so much of it as may be desired, is covered. The ends of the turn on the forehead and occiput are then secured by two or three more circular turns around the head.

Borsch's Eye Bandage.—Take a bandage two and a half or three inches in width and long enough to go two or three times around the head. Pass it around the head horizontally from the occiput across the eyes. When it is desired to leave one eye uncovered attach a narrow bandage to the posterior part of the horizontal bandage, carry it over the top of the head, pass it beneath the horizontal portion, and fold it back so as to uncover the eye.

Liebreich's Eye Bandage.—Take a strip of flannel from six to ten inches in length, two and one-half inches in width, and sew two tapes to each extremity. This may be applied obliquely over one eye, or transversely so as to cover both eyes and hold the dressings in place, the tapes being carried around the head and tied posteriorly or in front.

FIG. 58.—Barton's bandage.

Figure-of-8 Bandage for the Lower Jaw (Barton's Bandage).—Take a bandage two inches wide and five yards long. Place the extremity just below the external occipital protuberance. Carry the bandage over the right parietal bone, obliquely across the vertex, down the left side of the face, beneath the chin, up the right side of the face, obliquely across the vertex, over the left parietal bone to the starting-point; thence around the right side and along the lower jaw, across the front of the chin, around the left side of the jaw to the back of the neck, thence across the right parietal bone as in the beginning, repeating these figure-of-8 turns as often as necessary.

Figure-of-8 or Spica Bandage of the Shoulder.—Place the end of a two and one-half inch bandage on the upper part of the arm and fix it by two or three turns around the arm; thence carry the bandage across the front (or back of the chest, depending on the direction of starting) to the opposite axilla, across the back to the point of starting

upon the arm; then around the arm, across the chest, through the opposite axilla, and so on, each turn overlapping the preceding one by two-thirds and ascending from the arm along the shoulder to the neck.

The *descending spica* may be applied by beginning in the sound axilla, carrying the bandage across the front of the chest, across the opposite shoulder, beneath the axilla, around the shoulder, across the

FIG. 59.—Spica bandage.

FIG. 60.—Figure-of-8 bandage of the elbow.

back to the point of beginning; thence across the front of the chest and around the shoulder at a lower point, each turn overlapping the preceding one, but in a direction *downward* along the arm. If desired one of the loops of the figure-of-8 may be made around the neck instead of through the opposite axilla. The figure-of-8 is sometimes applied around both shoulders, crossing on the back or in front.

Figure-of-8 Bandage of the Elbow.—Place the end of a two and one-half inch bandage on the elbow, secure it by two or three turns, then carry it around the arm a little above the joint, making a circular turn, then obliquely across the front of the joint to the upper part of the forearm, around which a circular turn is made. It is again carried across the front of the joint to the arm and around it at a slightly lower point than the preceding turn, and so on, descending the arm and ascending the forearm until the joint is covered.

Figure-of-8 Bandage for the Forearm or Leg.—Secure the bandage by two or three turns around the arm at the elbow, or the leg just below the knee. Carry the bandage obliquely downward to a point about the middle of the leg, around which a circular turn is made; thence upward obliquely around the leg to the beginning, around which a circular turn is made at a slightly lower point than the first turn; thence again downward obliquely across the leg and around the same at a lower point than the preceding turn, and so on, both loops of the figure-of-8 descending until the leg is entirely covered.

FIG. 61.—Spica bandage of the thumb.

Figure-of-8 Bandage of the Thumb.—Fix the end of an inch and a half bandage by two circular turns around the wrist. Then carry it obliquely over the dorsal surface of the thumb to its distal extremity, around which a circular turn is made. The bandage is then carried upward over the back of the thumb to the wrist, around which a circular turn is made. These turns are repeated, gradually ascending from the point of the thumb and descending or remaining stationary around the wrist.

Spiral Reverse Bandage of the Forearm.—Secure the bandage by two or three turns about the wrist and cover in the hand by figure-of-8 turns around the wrist and hand. The bandage is then carried up the forearm by means of spiral reversed turns, the reverses being made as follows: The roller end of the bandage is carried up somewhat obliquely to the axis of the limb, leaving a portion of free bandage from four to six inches in length. The thumb or finger of the left hand is placed upon the lower half of the last turn, holding it in place while the free end is reversed or folded back on itself and

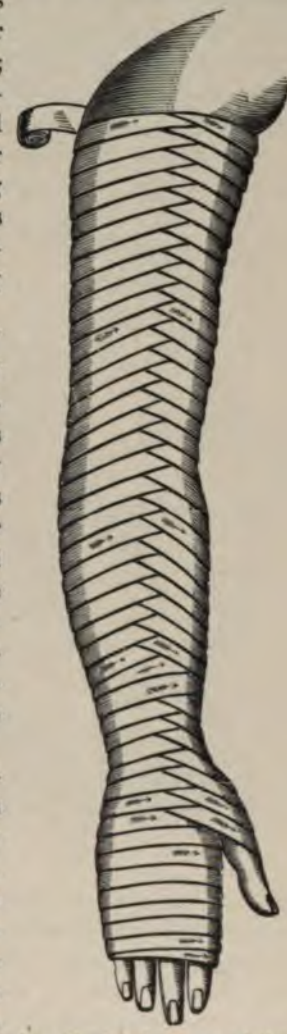


FIG. 62.—Spiral reverse of the upper extremity applied.

carried around the limb to be again reversed as before. The reversed points should be in line, in order to give the bandage a neat appearance.

Spiral Bandage of the Finger.—Secure the end of a bandage, one to one and a half inches in width, around the wrist. Carry the bandage obliquely across the back of the hand to the base of the finger to be covered, thence to its tip by oblique or spiral turns. Here a circular turn is made and the finger is covered by ascending spiral turns until the base is reached and the bandage carried obliquely across the back of the hand and around the wrist, where it is secured by pinning or by splitting the end and tying. All the fingers may be separately bandaged at the same time in this manner.

Velpeau's Bandage.—Place the hand of the affected side upon the opposite shoulder, with a layer of cotton between the extremity and the chest. Take a bandage three inches wide and ten or twelve yards long. Place the end in the axilla of the sound side. Carry the bandage over the shoulder of the affected side near its outer part; then downward along the outer and posterior surface of the arm behind the elbow and obliquely across the front of the chest to the point of beginning. These turns should be repeated, in order to fix the bandage. The bandage is then carried from the point of beginning in the sound axilla transversely around the thorax, over the elbow, across the front of the chest to the point of beginning; thence over the shoulder a little nearer the neck, down the outer and posterior surface of the arm behind the elbow, through the axilla, and so on alternately until the arm and forearm are firmly bound to the chest, the turns over the shoulder ascending towards the neck and those behind the arm and elbow advancing towards the front until the elbow is reached, the transverse turns ascending from the point of the elbow upward to the shoulder. The bandage should be securely fastened by pins or strips of adhesive plaster to prevent slipping.

FIG. 63.—Velpeau's bandage.

Figure-of-8 or Spica Bandage of the Hip or Groin.—Place the end of a four-inch bandage in the groin of the affected side, carry the bandage down the inner side of the thigh at a low point, behind the thigh, upward along the outer side, obliquely across the front of the thigh and lower part of the abdomen just below the crest of the opposite ilium, around the back to the opposite side, to the point of beginning. These turns are repeated, each one overlapping the preceding in an ascending direction. In some cases it is advisable to alternate the figure-of-8 turns with circular turns around the abdomen.

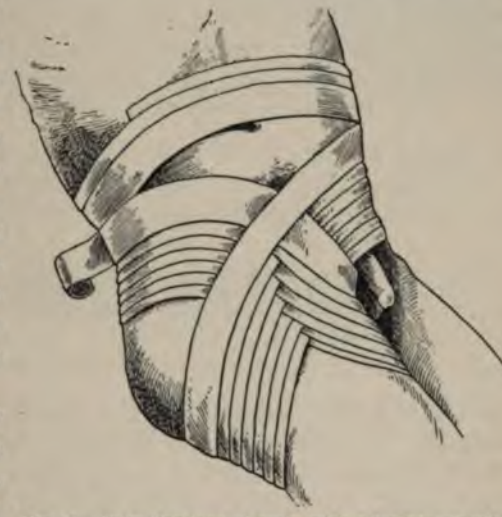


FIG. 64.—Spica bandage of groin with alternate circular turns around the abdomen.

The Double Figure-of-8 or Double Spica of the Hips or Groins.—Secure the bandage by a couple of turns around the abdomen just above the iliac crests. Then carry it, for example, from the right side obliquely across the lower part of the abdomen to the outer surface of the left thigh, around it and upward and outward through the groin, around the back of the pelvis to the right side, to a point just below the crest of the ilium, thence obliquely over the right groin, down the inner side of the thigh and around the outer side to the front and obliquely across the lower part of the abdomen to the opposite side, these turns being alternately repeated as long as necessary.

FIG. 65.—Spica bandage of foot.

Figure-of-8 Bandage of the Foot.—Secure the end of a two inch or two and one-half inch bandage by a couple of turns just above the ankle; carry the bandage obliquely over the dorsum of the foot to the metatarsophalangeal articulation, making a circular turn here. Carry the bandage upward over the metatarsus obliquely across the instep, around the point of the heel and obliquely across the opposite side of the foot, crossing the first turn in the median line of the foot; thence around the foot a

little nearer to the ankle, and around the heel a little nearer to the ankle, until the foot is covered, each loop of the figure-of-8 ascending.

BANDAGING OF STUMPS.—The recurrent bandage is generally preferred. Take a bandage from two to three inches wide and six or eight yards long; place the extremity on the anterior or posterior surface of the limb, four or five inches above the end of the stump; carry the bandage over the end of the stump, then upward to a point opposite the beginning; then back and forth in the same way until the end of the stump is covered. The ends of the turns which have

FIG. 66.—Recurrent bandage of the stump.

been held by an assistant are now secured by circular turns of the bandage. The bandage may be continued to a higher point on the limb by circular, spiral, or spiral reversed turns. If near the body, the bandage should be carried around the chest or the pelvis in figure-of-8 form. Whenever necessary the bandage should be secured in place by means of strips of adhesive plaster attached to the bandage and to the skin above it.

HARD BANDAGES.—In order to make them hard and capable of acting as splints, bandages are impregnated with various substances, as plaster of Paris, starch, silicate of sodium, glue, dextrin, etc. Plaster-of-Paris bandages are prepared as follows: Cheese-cloth or crinoline is made into bandages from two to four inches in width and about five yards in length. These are laid upon a table and plaster of Paris (sulphate of calcium) is dusted freely over them and rubbed into the meshes with a spatula. The bandage is then rolled loosely, and is ready for use. The limb or part to which the plaster bandage is to be applied is prepared by padding all bony protuberances with cotton and encasing the part in a flannel bandage; or the part may be encased in absorbent cotton, unless a very snug fit is desired. The plaster bandage is soaked in warm water until air-bubbles cease to escape. It is then removed, the excess of water squeezed out, and the bandage placed, snugly and as evenly as possible, each turn overlapping the preceding one about one-half until from three to six layers of bandage have been applied. It is not necessary to use many layers of bandage provided cream of plaster is well rubbed into

the surface of the bandage after it has been put on. After applying the bandage the surface is rendered smooth by wetting and rubbing dry plaster into the surface. The limb should be held steady until the plaster sets, which takes from ten to fifteen minutes if the plaster is of good quality. The plaster bandage should always be freshly prepared and kept in air-tight jars or cans in a dry place. If the plaster deteriorates, as it may by absorbing moisture, baking it in a hot oven for half an hour will drive away the moisture and render it again suitable for use.

When, in applying a plaster cast, it is known that a fenestrum will have to be made, as in compound fractures, it is sometimes advisable to strengthen the cast by incorporating strips of zinc or of wood.

Removal of the Plaster Bandage or Cast.—This may be effected by leaving a stout cord long enough to project at both ends, wrapped in paraffin paper, between the cotton and the plaster. After the plaster has set, a strong piece of wire can be drawn beneath the plaster by means of the cord, making a Gigli saw, and the plaster sawed open. The cast may be removed by means of the Darrach plaster-cutter, which is probably the best instrument of that kind in use; or it may be divided by means of a strong sharp knife, or by various knives, saws, and shears which have been devised for the purpose. It is convenient, when the plaster has been applied to an extremity, to split it on opposite sides so that it can be removed in two sections. Afterwards the two sections can be replaced and secured by a bandage or adhesive plaster and one or both may be removed at pleasure for purposes of dressing or inspection.

The Starch Bandage.—This is prepared by mixing starch with cold water and boiling it until a clear mucilaginous liquid is obtained. The part to which the dressing is to be applied is prepared as in the case of the plaster-of-Paris bandage, using a bandage of cheese-cloth or crinoline outside of the cotton or flannel bandage. The starch is rubbed into the meshes of the bandage, another bandage is added, into which the starch is rubbed, and so on, until the necessary number of layers have been put on. The starch bandage requires a day or two to become thoroughly dry.

Silicate-of-Sodium Bandage.—This is made in the same manner as the starch bandage except that the outside bandage of cheese-cloth or crinoline is covered over with a solution of silicate of sodium or potassium by means of a brush, other layers being applied successively and brushed over in the same manner. This also requires about twenty-four hours for drying. This bandage may be removed by soaking in warm water and cutting with shears or saw.

CHAPTER XII.

THE ROENTGEN RAY.

ALTHOUGH for years something had been known of the wonderful properties of the cathode or negative rays resulting from the passage of an interrupted current of high potential through a glass or Crookes tube reduced to an almost perfect vacuum, it remained for Roentgen, of Wurzburg, in 1895, to demonstrate their great value in revealing the contents of bodies opaque to all other forms of light.

The exact nature of the Roentgen rays is unknown. They are invisible, cannot be deflected, reflected, or refracted, do not produce heat, and are uninfluenced by magnetism. They cause fluorescence when passed through tungstate of calcium, platino-cyanide of barium, and platino-cyanide of potassium. They penetrate all known substances to a greater or less degree, and, if allowed to fall upon a photographic plate after penetrating a body, a photograph of the shadows caused by the partial interruption of the passage of the rays (a skiagram) is made; that part—as bone—which is densest or which interferes most with the passage of the rays causing the darkest shadow, that part which is less dense—as muscle—causing a *lighter* shadow, and that part which is least dense—as fat and skin—causing the *faintest* shadow. A substance more nearly impenetrable than bone, such as the metals, lead, iron, etc., would cause a darker shadow than bone.

THE APPARATUS.—The apparatus consists of a Crookes tube, an electric machine, a photographic plate, and a fluoroscope.

The *Crookes* tube, of various shapes, has sealed into it two platinum points to which the negative and positive wires can be attached. The tube has been reduced to an almost perfect vacuum, containing only about one-millionth part of an atmosphere. A tube of high vacuum, called a *hard* tube, has greater penetrating power than a tube of low vacuum, or the *soft* tube, but the latter gives greater differentiation between the less opaque structures.

The *current* may be obtained from a static machine or from a Ruhmkorff coil. In the static machine the current is carried directly to the tube. When the Ruhmkorff coil is used the primary current is obtained from some other source, such as storage batteries, dynamos, or cells. The primary current passing through the Ruhmkorff coil

causes, by induction, a secondary current through the coil and this is conveyed to the tube. In either case an *interrupter* for making and breaking the current is required. For doing good work the current must be of high ampèrage and capable of giving a *fat* spark at least eight inches in length.

The photographic plate may consist of any ordinary plate or of those specially prepared for Roentgen ray work. The plates are properly protected from sunlight by enclosing in dark-colored paper. Upon this plate a negative picture is taken of the *shadows* caused by the Roentgen rays; hence the picture is called a *skiagram*.

The Fluoroscope.—The fluoroscope consists of a pyramidal box made of opaque card-board, the apex being open, while the base is covered with a fluorescent salt—tungstate of calcium or platinocyanide of barium or of potassium.

USE OF THE APPARATUS.—The room containing the apparatus must be darkened and the tube fixed to a stand with a movable arm, which permits its adjustment to various positions. The two wires (anode and cathode) are attached to the tube and the electric current is turned on. When in good working order, the light in the tube is of an apple-green color, while the platinum anode is red hot. For parts not too thick, as the hand or upper extremity, or in any case for a preliminary examination, the fluoroscope may be used. The hand, for example, is held against the base of the fluoroscope, while the open end of the instrument is applied to the observer's eyes. The hand, with the instrument, is then brought to within from six to ten or twelve inches of the tube. The bones can be seen and foreign bodies, especially metallic ones, can readily be detected. To take a skiagram, the photographic plate enclosed in its paper envelope is placed beneath the part with its sensitive side up. Some light covering, as a piece of cotton cloth, should always be placed over the part. Care should be taken to remove from the clothing all objects which may give misleading shadows, as buttons, pins, coins, etc. The tube is then brought into a perpendicular position within from twelve to fifteen inches of the part to be examined. As the rays come from the anode, this should be placed directly over the plate and part to be examined, in order to prevent distortion and a misleading skiagram. The length of exposure required depends on the efficiency of the apparatus and the thickness of the part examined, and varies from two minutes or less to half an hour or more.

Location of Foreign Bodies.—In locating foreign bodies—bullets, for example—the part should be examined with the fluoroscope from at least two directions, or at least two skiagrams from different points should be taken in order to show by triangulation the distance of the

body from the surface. Bullets or fragments of lead, iron, steel, tin, glass, stone, or wood, embedded in the tissues or contained in the viscera, are readily revealed. Iodoform and bismuth also give a good skiagram, and cavities or viscera injected with these substances are well shown. Renal, vesical, and prostatic calculi, and even gall-stones, have come out clearly in skiagrams. Gall-stones, however,

FIG. 67.—Skiagram of needle in knee.

on account of their slight density and the thickness of the liver, are difficult to skiagraph. Fractures and dislocations offer the greatest field for the Roentgen ray in determining the nature of the injury and whether satisfactory reduction has been accomplished; but it is important to remember that the skiagram does not always give the true shape and relation of the parts.

Diseased Conditions.—Many diseased conditions can be shown, as dead bone, bone abscess, bony tumors, osteosarcoma, and others. The outlines of the viscera—the heart, lungs, liver—can be shown, and often diseases of these organs, if accompanied by marked increase or diminution in density, can be recognized.

Therapeutic Effect.—So far not much is known of the therapeutic effect of the Roentgen ray, but that it is a powerful agent in acting on the tissues cannot be doubted. Cures have been reported of cases of lupus, rodent ulcer, epithelioma, carcinoma, and sarcoma.

Dangers of the Roentgen Ray.—Excessive or improper exposure to the rays causes dermatitis, and workers with the apparatus have lost

their eyebrows, eyelashes, and even the hair of the hands. Prolonged exposure in taking a skiagram may cause a burn in which the tissues are destroyed, slough, and leave an ulcer which requires an unusually long time to heal. A burn is more apt to follow the use of the Ruhmkorff coil than of the static machine. To prevent this the tube should not be placed too near the patient and the part exposed should always be protected by a light covering—even a cotton cloth may be sufficient. It is said that by interposing between the tube and the part exposed a sheet of thin aluminum or gold leaf spread on a card and connected with the earth by a grounding-wire, injury will be prevented by conducting away the currents of electricity which escape into the air around the tube.

CHAPTER XIII.

RESULTS OF INFLAMMATION.

SUPPURATION.

Suppuration frequently follows or complicates inflammation. As a result of injury—bacterial, mechanical, or chemical—the leucocytes and embryonal cells are deprived of life and converted into pus-corpuscles. Certain of the cells are dissolved or peptonized, and, with the serous exudate, furnish the *liquor puris* in which the pus-cells float.

Causes of Suppuration.—Experiments by several investigators, notably Councilman, Uskoff, and Grawitz, prove that pus can be produced by metallic mercury, turpentine, and croton oil, when introduced into the tissues under perfect aseptic conditions, in small glass capsules which are broken after healing. For practical purposes, however, the surgeon may consider suppuration as the result of the action of pathogenic organisms, though it is probably a chemical product (ptomaines) whose action on the tissue-cells produces pus. Park divides these organisms into two classes:

1. The *obligate* pyogenic germs, which produce pus under ordinary conditions. These are: The staphylococcus pyogenes (aureus, albus, citreus, etc.), the streptococcus pyogenes and streptococcus erysipelatis, the micrococcus lanceolatus, micrococcus tetragonus, the gonococcus, bacillus coli communis, and bacillus pyocyaneus.

2. The *facultative*, which produce pus under special conditions. They are: The bacillus typhi abdominalis, bacillus proteus, bacillus diphtheriæ, bacillus tetani, bacillus of malignant œdema, bacillus tuberculosis, bacillus of anthrax, bacillus of glanders, bacillus of leprosy, bacillus of pneumonia, bacillus of rhinoscleroma, bacillus of bubonic plague, and the bacillus of rauschbrand.

Besides bacteria, certain animal organisms low in the scale of life, as the amœba and coccidia, also produce suppuration.

Suppuration has been aptly described as a battle in which the armies are the cells of the tissues on the one side and the invading bacteria on the other. Many of the bacteria are destroyed by phagocytosis; and, on the other hand, many of the cells are destroyed and form pus-corpuscles, while others are dissolved by the peptonizing

action of the bacteria or the ptomaines, and with the serous effusion form the liquid in which the corpuscles float. *Chemotaxis* is the force which acts between the cells and the bacteria—either to attract or repel—hence it is called *positive* or *negative*. The ptomaines or toxins of the bacteria seem capable of producing pus without the presence of the micro-organisms, as is seen in cases of suppurating buboes.

Microbes gain entrance to the system in various ways, through a lesion of the skin or mucous membrane in the alimentary or respiratory tracts, or they may even enter through the unbroken tissues when rubbed on the surface. If they do not locate at some point near the avenue of entrance, they may be taken up by the circulation and carried to distant parts of the body where conditions rendered favorable by injury, disease, or peculiar anatomical construction invite their location. The *predisposing cause* is anything which diminishes the vitality of the tissues, either constitutionally, as certain diseases,—tuberculosis, syphilis, malaria,—or locally, such as the result of blows or slight injuries.

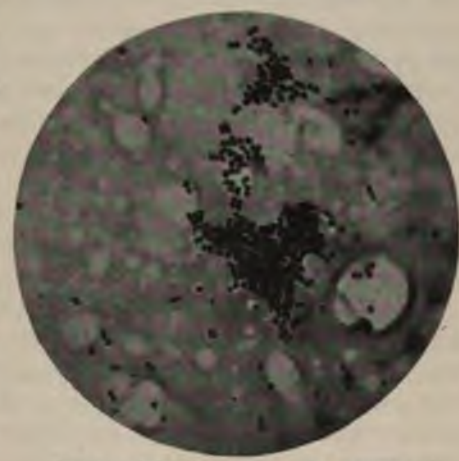


FIG. 68.—Staphylococcus pyogenes aureus.

PUS is an opaque, yellowish-white or greenish-white fluid, of the consistency of milk or cream, slightly acid in the recent state, but later slightly alkaline from the formation of ammonia. It is usually odorless, has a specific gravity of about 1030, and on standing separates into *pus-serum* and *pus-corpuscles*. Pus-serum contains an albuminous substance called peptone, and the same proportion of salts and water as the blood. Pus-corpuscles consist of dead and dying leucocytes and proliferated fixed tissue cells, which contain many nuclei in the process of fragmentation, an evidence of disintegration. Acetic acid clears up the corpuscles and makes the nuclei plainer. Caustic potash dissolves the pus-corpuscles. Pus is sometimes blue, from the bacillus pyocyaneus; red, from another chromogenic bacillus; or orange-colored, from the presence of hæmatoidin crystals,—indicating an unfavorable prognosis. It may be offensive in odor from the presence of the bacillus pyogenes fœtidus or from other

causes. *Ichorous pus* is decomposed pus in which the corpuscles are broken down, and is frequently acid in reaction. When mixed with blood it is called *sanious pus.*

Symptoms of Suppuration.—During acute inflammation the formation of pus is indicated by the inflammatory symptoms becoming more marked; the local pain, redness, swelling, and heat are increased and there is often a sensation of throbbing, and chill, fever, and sweats may be present. If near the surface, the hardness and resistance give way and fluctuation may be detected. *Phlegmonous* inflammation—from infection with streptococci—is often followed by a diffused suppuration in which the pus invades the connective tissues over a considerable area. It may involve the greater portion of a limb with swelling, œdema, and bogginess of the affected parts, and fluctuation may not be detected until great destruction of tissue has taken place. Lymphangeitis and lymphadenitis are frequent.

Abscess.—An *abscess* is a circumscribed collection of pus, due to a limited inflammation. The cause is the invasion by the pyogenic microbes (staphylococci) of tissues weakened by disease, injury, anatomical construction, or other conditions favorable to the growth of the organisms. The microbes provoke a multiplication of leucocytes and connective-tissue cells, which accumulate in the lymph spaces and surrounding tissues, producing thickening and swelling of the parts. As a result of the interference with the circulation and the peptonizing action of the ptomaines upon the cells, liquefaction takes place at the point where the inflammation is most active, and thus an abscess is formed, surrounded by hard, thick walls lined with granulations.

Coagulation necrosis occurs most frequently in the internal organs, though it may occur in the skin. It is due to embolism of a terminal artery or to the effects of micrococci, which produce death of the cells by slow degrees. The tissues are yellowish or whitish in appearance, changing to a caseous mass, which may liquefy and form an abscess or become absorbed or calcified.

Cold abscess is chronic in character, and usually has a tuberculous or syphilitic origin. It is characterized by its insidious progress, frequently originating in diseased bone and gradually dissecting towards the surface. There is usually no redness or pain, and fluctuation is difficult to detect until the abscess reaches the surface. The pus may be due to a mixed infection, but the tubercle bacillus alone is capable of producing pus. The granulations are partly organized and form a membranous wall around the abscess—the "pyogenic membrane."

Furuncle or boil is a variety of abscess in the integument. It is

caused by the penetration of staphylococci into the epidermis along the roots of hairs or into sebaceous glands, and their development at the bottom of the hair-follicle, causing inflammation and coagulation necrosis or a slight local gangrene with the formation of a slough. This separates from the surrounding tissues by the liquefying or peptonizing action of the pus organisms and forms the "core" of the boil. Externally a boil appears as a small pustule beneath the epidermis; the deeper tissues soon swell, become hard, elevated, red, and tender, and if not treated in time the apex softens, pus is discharged with the "core," leaving a crater-like cavity which heals by granulation.

Carbuncle is a multiple boil, which not only involves the skin, but extends to the subcutaneous tissues. It often occurs in those whose vitality is weakened by such diseases as diabetes, and is most frequently situated on the back of the neck or on the posterior surface of the trunk. In appearance it resembles a number of boils closely united, with from one to half a dozen points, which later become openings. It varies in size from two to twelve or fourteen inches in diameter.

Localized abscesses may occur in any part of the body. Many of them have special names, as retropharyngeal, perinephric, psoas, subdiaphragmatic, empyema or pleural abscess, liver abscess, and metastatic abscess.

Treatment.—The cardinal rule in the treatment of abscess is to evacuate pus, then provide free drainage, and promote the process of healing. Often suppuration may be prevented by making free incisions in the congested area, thus relieving blood stasis and preventing death of the tissues. *Boils* should be treated as early as possible by free incision and antiseptic dressings,—hot fomentations of bichloride solution. *Carbuncles* are treated by *excision* with or without skin-grafting, or *incisions* with curettage of the gangrenous tissues. *Abscesses of the deeper tissues* or of dangerous anatomical regions such as the neck should be opened by the Hilton-Roser method (Gerster), which consists in incising the skin and fascia and burrowing through the deeper tissues with a blunt instrument, as a grooved director or hæmostatic forceps. For irrigation of abscess cavities use bichloride of mercury 1 : 5000 to 1 : 10,000; carbolic acid, 2 per cent.; peroxide of hydrogen, or boracic acid. In suitable cases the abscess may be filled with iodoform mixture—10 per cent. in glycerin.

ULCERATION.

An *ulcer* is a loss of substance on the surface of the body or of an organ, caused by injury or disease. It is a common result of inflammation and follows death of the tissues in small particles, as distinguished from gangrene, which is the death of the tissues *en masse*. When bone is affected by ulceration, the term caries is used. An ulcer is really a part of an abscess cavity.

In a *simple* ulcer the edges and bottom are covered with granulations of a pinkish-white color, and the portion between the edge of the ulcer and the skin by a pale bluish pellicle—the young epidermis—gradually extending over the granulations.

The *chronic*, *indolent*, or *callous* ulcer is one which does not tend to heal, or heals very slowly. The granulations are paler and smaller than in the healthy ulcer, the edges are thickened and indurated and may be undermined, with a thin purulent discharge. Sometimes instead of granulations the base is covered with a thin layer of necrotic tissue. *Inflamed ulcers* are those with congested granulations, which bleed readily, and the surrounding skin is likely to be red and indurated. *Varicose ulcers* occur in the lower extremity in connection with varicose veins. *Irritable*, *painful*, or *erethistic ulcer* is one in which sensitive nerves are involved, as in ingrowing nail and fissure of the anus. *Perforating ulcer*, often seen in the foot about the metatarsophalangeal joint, is probably of trophic origin. *Phagedenic ulcer* is a rapidly spreading ulcer without granulations, and is probably caused by local or constitutional debility or microbic invasion. *Rodent ulcer* is a form of epithelioma (Green).

Treatment.—For the *simple*, *healthy* ulcer no treatment is required except aseptic dressings, quiet, and protection from injury. For the *chronic*, *indolent*, or *callous ulcer*, stimulate by the application of nitrate of silver or the actual cautery, and strap it with adhesive plaster or apply a rubber bandage. Or scrape the surface, cut through the edges by radiating incisions, or dissect out the ulcer and use skin-grafts. For *inflamed ulcers* use soothing applications,—ointment of oxide of zinc, carbolic acid, or subnitrate of bismuth in powder. *Varicose ulcers* are treated on general principles and a rubber or flannel bandage worn or an operation performed. *Irritable*, *painful ulcers* require cauterizing with pure carbolic acid or nitrate of silver, or incision or excision. *Perforating ulcer* may be treated by nerve stretching, removal of diseased bone, and sometimes amputation of part of the foot is necessary. In *phagedenic* ulcer cauterize with nitric acid or the actual cautery and give stimulants internally.

FISTULA AND SINUS.

A *fistula* is a narrow tract connecting the surface of the body with an internal cavity, or connecting two adjacent cavities or canals. An example of the first is a complete fistula in ano, and of the second a vesicovaginal fistula.

A *sinus* is a narrow channel, sometimes tortuous, leading from the surface of the body into an unhealed abscess cavity. A sinus is sometimes seen after appendectomy or in cases of osteomyelitis. Its persistence means the presence of some irritating substance which prevents healing, such as a ligature, piece of bone, or other foreign body. The *diagnosis* is usually made by the presence of a slight discharge from a small granulating surface, and the introduction of a probe discloses the opening leading to the abscess cavity or to the cavity of another organ. The *treatment* consists in removing any foreign body, laying open the channel and dissecting out or destroying the pyogenic membrane which often lines the tract, approximating the parts by sutures, or packing with gauze and allowing healing to take place by granulation.

CHAPTER XIV.

GANGRENE.

Gangrene means the death of the tissues in large particles, or *en masse*. Mortification, mummification, and necrosis are terms used to express the same condition, though *necrosis* is usually applied to death of bone. Sphacelus is the term applied to the slough or mass of tissue separated.

ETIOLOGY.

The causes of gangrene are: (1) Interference with the supply of nutritive material, or injury or destruction of the cells of the tissue, such as by obstruction in the arteries, as by ligature, rupture, or embolism; (2) obstruction in the capillaries from inflammation, causing "coagulation necrosis;" (3) obstruction in the veins alone—this is rarely a cause of gangrene; (4) weakness of the heart's action; (5) injury by mechanical violence sufficient to destroy the tissues; (6) excessive heat or cold; (7) the action of corrosive chemicals, such as acids and alkalies; (8) secretions from wounds in some cases; and (9) injury or disease of the nervous system. Much depends on the normal resistance of the tissues. Diabetes, typhoid fever, and other wasting diseases reduce resistance. Atheroma and obliterating endarteritis, producing gradual occlusion of the vessels, frequently cause senile gangrene.

VARIETIES.

The two principal varieties of gangrene are the *dry* and the *moist*, and all forms belong to one or the other. *Dry gangrene* occurs in parts naturally having little fluid, or in which the tissues are enabled to dry out, as when the obstruction is in the main artery supplying the part. *Moist gangrene* occurs in tissues well supplied with fluid and muscle, especially if there is a sudden arrest of the circulation, as from obstruction in the principal vein or in the capillaries. This leaves the tissues in a sodden condition favorable for the growth of bacteria, with the development of gas and offensive odors. *Coagulation necrosis* occurs in the internal organs as a result of embolism, the cells of the part from which the circulation is cut off dying and undergoing a change which resembles coagulation.

SENILE GANGRENE is a typical form of dry gangrene. It is usually caused by thrombosis from disease of the arteries, atheroma,

or obliterating endarteritis aided by weakness of the heart. While most frequently seen in persons over fifty years of age, it may also occur in young persons: "a man is as old as his arteries."

Symptoms of Senile Gangrene.—Premonitory symptoms, as pain of a burning character, numbness, coldness, absence of sensation and circulation in the toes or foot, may be felt for several days or weeks before the disease becomes well pronounced. Frequently a slight injury, as an abrasion from a shoe, becomes dark red, gradually changing to purple or greenish black, and the disease slowly advances from the toe to the foot and may extend to the leg. The dead part is dark brown or black, with little or no odor, and has a shrivelled, leathery appearance,—mummified. A red line of demarcation, formed by the granulation of the sound tissue, indicates the arrest of the process and may form at any point. Constitutional symptoms are not serious unless the emboli are carried to internal organs or the disease involves a large portion of the foot or leg, and septicæmia results, with chills, fever, sweats, diarrhœa, coma, and probably death.

FIG. 69.—Dry gangrene of the feet.

SIMPLE TRAUMATIC GANGRENE belongs to the moist variety and is caused by sudden arrest of the circulation by injury to the vein or artery, or both, as in fractures, from the faulty use of bandages, or as the result of inflammation. Sometimes the vitality of the tissues is immediately destroyed by the traumatism.

Symptoms.—In a foot or hand which has been injured the circulation ceases, the skin becomes pale, cold, and waxy in appearance; pain subsides and is succeeded by loss of sensation; in a few hours or a day or two, the skin changes to red, purple, mottled green, and black, or greenish black; the extremity swells from the escape of the watery portions of the blood, which soak through the muscles and form blisters or bullæ on the surface, filled with a reddish or brown fluid; and gas may form in the parts from the action of saprophytic organisms, giving rise to a crackling or emphysematous sensation on pressure. The entire mass becomes soft and pulpy, with a most offensive odor. If a large area is affected, septicæmia develops. A line of demarcation usually appears, but it may be too late to be of service.

TRAUMATIC SPREADING GANGRENE, GANGRENOUS EMPHYSEMA, MALIGNANT ŒDEMA, FULMINATING GANGRENE.—This is a variety

of traumatic gangrene to which is added an infectious process caused by the presence of certain pathogenic organisms—the bacillus of malignant œdema, the bacillus aerogenes capsulatus, and, possibly, a variety of streptococcus. Hospital gangrene, so common in pre-antiseptic days, probably belongs to this variety. In the experiments of Koch on animals, symptoms of hospital gangrene were produced by the injection of a streptococcus.

Symptoms.—The symptoms may begin within a few hours after the receipt of the injury, the skin appearing reddish brown, changing to green and black. The parts become swollen, brawny, and œdematous, with bullæ on the surface from hemorrhagic extravasations, and emphysematous crepitation from the gas in the tissues. The process advances with frightful rapidity and in less than twenty-four hours may involve the entire extremity. There is no tendency to the formation of a line of demarcation. Symptoms of toxæmia, with rapid pulse, elevated temperature, delirium, and profound prostration come on, and death closes the scene.

A young man was bitten by a tiger, severe wounds being inflicted extending from the knee-joint to the foot. The patient was anæsthetized and the parts carefully cleansed with antiseptic solutions and dressed. Twelve hours after the injury the patient was delirious, with elevated temperature, rapid pulse, and involuntary evacuations. The leg was cold, dark purple in spots, swollen, crackling with emphysema, and emitted a most disgusting odor. Eighteen hours after the injuries were received the thigh was amputated, but the patient died four hours later.

GANGRENE FROM BURNS OR FROST-BITE may result from destruction of the tissues, owing to intense heat or cold. It may be of the dry or the moist variety. In frost-bite the extremities are usually involved, as the toes or feet, fingers, hands, nose, and ears. The parts are at first blanched, without sensation, but afterwards turn black. A line of demarcation forms.

FIG. 70.—Gangrenous stomatitis.

CANCRUM ORIS, NOMA, OR GANGRENOUS STOMATITIS is a form of gangrene observed in children, especially as a complication or sequel of one of the eruptive fevers. It properly belongs in the class with hospital gangrene, as it is the result of bacterial infection in patients under bad hygienic conditions.

Symptoms.—The first symptom observed may be a dusky-red spot on the outer surface of the cheek, and on examination an indurated ulcer with sloughing surface will be found at the opposite point on the inside. It extends rapidly, and may destroy the lip or cheek, or even the gums and bones. An offensive discharge escapes from the ulcer, temperature and pulse are elevated, the patient is greatly depressed and usually dies within five days from exhaustion. *Noma pudendi* may occur in female children.

DIABETIC GANGRENE occurs in elderly persons with diabetes, the cause being disease of the peripheral nerves, arteriosclerosis, or endarteritis, aided by the diminished vitality of the tissues. It is

FIG. 71.—Diabetic gangrene of little toe extending along the foot to external malleolus.

usually of the moist, but may be of the dry, variety. The prognosis is grave, on account of the complications likely to arise, as pneumonia, carbuncle, bed-sores, diabetic coma, and the fact that such patients bear operations poorly.

NEUROPATHIC GANGRENE is caused by disease or injury of the vasomotor or trophic nerves, and is seen in the insane, in paralyzed limbs, after injuries to the spinal cord, or in old and feeble individuals, or after long-continued fevers. A slight injury, as the pressure from lying in bed, may be followed by sloughing and extensive destruction of the parts, even extending to the bone. To this class belongs *decubitus* or *bed-sore*.

RAYNAUD'S DISEASE, or SYMMETRICAL GANGRENE, is caused by contraction of the peripheral blood-vessels from an affection of the vasomotor nerves, sometimes from syringomyelia. It commonly occurs in young persons, on both sides of the body, and may affect the tip of the nose, the cheeks, ears, toes, and fingers, producing the "dead" or "cold finger" seen after bathing in cold water. The parts are cold, numb, and pale, then dark; blisters and sloughs may

appear, but are soon thrown off and healing follows. The attacks may become frequent.

THE GANGRENE OF ERGOTISM is caused by the use of grain containing ergot. Spasm of the arterioles results from irritation of the vasomotor nerves, and the fingers, toes, or entire extremities may suffer dry gangrene.

AINHUM is a form of spontaneous dry gangrene found among the negroes in Africa and the West Indies. A band of fibrous tissue forms around the toe, gradually tightening like a rubber band until gangrene or spontaneous amputation of the toe results. It may last for from one to ten years.

Gangrene from extravasation of urine and from strangulated hernia is described elsewhere.

TREATMENT OF GANGRENE.

In phlegmonous inflammation, threatening to result in gangrene, free incision may relieve the congestion, restore the circulation, and prevent death of the tissues. Depression and prostration accompany most forms of gangrene, so that tonics and stimulants are indicated.

Senile Gangrene.—On the appearance of the first symptoms put the patient to bed, dress the part antiseptically and wrap in cotton to keep it warm. As long as the gangrene is confined to the toes, wait for a line of demarcation; if it extend to the foot or leg, amputate at once above the point at which experience has shown the process is likely to extend,—that is, just above the knee.

Embolism or *thrombosis* causing gangrene is usually located at the bifurcation of the popliteal artery.

In *simple traumatic gangrene* confined to a small area, treat the parts antiseptically, relieve tension, make ample provision for drainage, and await the formation of a line of demarcation. If the gangrene result from injury to the main blood-vessels and show a tendency to spread, amputate at once above the point at which the blood-vessels have been injured, without waiting for a line of demarcation to form.

Traumatic spreading gangrene, *gangrenous emphysema*, *malignant œdema*, *fulminating gangrene*, and *cancrum oris* require prompt and energetic treatment, as the loss of an hour may be a serious matter and turn the scale against the patient. If the limb be affected, amputate high up and at the earliest possible moment, in order to get well above the area invaded by the micro-organisms. If the process occur on the body or face, as in *cancrum oris*, remove the gangrenous tissue and cauterize with the actual cautery or with nitric acid.

Gangrene from *burns* and *frost-bite* should be treated on general

principles and a line of demarcation awaited; but if septicæmia occur, amputate at once.

Diabetic gangrene should be treated in the same way as senile gangrene.

For *neuropathic gangrene*, in the form of bed-sores, much can be done in the way of prevention by the use of water-beds, scrupulous cleanliness, bathing the parts subjected to pressure with dilute alcohol, and changing the patient's position in bed as frequently as possible. After sloughing, relieve pressure on the ulcer and treat antiseptically.

Raynaud's disease is treated by protecting the extremities against sudden changes of temperature. For overcoming the arterial spasm electricity has been used.

CHAPTER XV.

THROMBOSIS AND EMBOLISM; TRAUMATIC FEVER, SEPTICÆMIA, AND PYÆMIA.

THROMBOSIS AND EMBOLISM.

THROMBOSIS is the formation of a blood-clot in the heart or blood-vessels during life. The clot thus formed is called a *thrombus*. An *embolus* is a fragment of thrombus detached and carried by the circulation until arrested in some small blood-vessel, where it may form a second thrombus, produce an infarct, or, if infected, a metastatic abscess. Thrombosis occurs most frequently in the veins, and is due to one or more of three causes (Green),—damage to or absence of the endothelium, retardation of the blood-stream, and certain conditions of the blood. Injury of the endothelium may be the result of disease, as inflammation; or traumatism, as section, rupture, ligation, or torsion of the vessels. Phlebitis with thrombosis may originate from extension of inflammation from neighboring tissues, or in acute diseases, as enteric fever. Thrombosis may occur on the valves of the heart as a result of endocarditis. Slowing of the blood-stream from weakness of the heart causes the leucocytes to cling more closely to the vessel walls, and thus favors the formation of a thrombus. Conditions of the blood favoring thrombosis are found after profuse hemorrhage, in inflammatory diseases, as pneumonia, pleurisy, pyæmia, septic fevers, and in the presence of micro-organisms in the blood-vessels.

Thrombi are of two kinds,—*red* and *white*,—red originating in stagnant blood, as after ligation of an artery or vein, while the white forms in blood which is still circulating, as in the sac of an aneurism; a mixed variety may be produced in a languid blood-stream. A *thrombus* may obstruct, partially or completely, the vein or artery in which it lodges. Once formed it may extend by the gradual deposition of fibrin on its surface until it reaches the first collateral branch, where its growth is usually arrested. Sometimes, however, the process is continued, and a clot may fill an entire vein, occasionally extending from the foot to the thigh. The portion of the thrombus projecting into the next branch may be broken off in the blood-current and form an embolus. This embolus is carried by the venous current to

the liver, where it may lodge, or to the heart, thence to the lungs, and, if very small, through the lungs back to the heart and into the arterial system, until it meets with a vessel too small to admit its passage; here it lodges and forms an embolism. If embolism occur in a terminal artery, as in the brain, lungs, spleen, and kidneys, the part supplied by this vessel is deprived of its circulation and an infarct with coagulation necrosis occurs; or, if the embolus originates from a suppurating thrombus, a metastatic abscess is formed. Emboli may lodge in the arteries of the extremities and cause gangrene of the limb, or in a mesenteric artery, causing gangrene of the intestine.

CHANGES IN THROMBI.—Thrombi may undergo resolution or absorption and the vessel be restored to its former condition; or they may become organized and permanently occlude the vessel; or calcified and form phleboliths; or they soften and disintegrate and form emboli.

TREATMENT.—If the thrombus be in an extremity, keep the patient quiet and avoid all manipulation which might detach emboli from the thrombus until a sufficient period has elapsed, at least three weeks, for its absorption.

TRAUMATIC FEVER, SEPTICÆMIA, AND PYÆMIA.

ASEPTIC WOUND FEVER, or TRAUMATIC FEVER, is a common result of operations which have been performed under the most thorough aseptic precautions, or after the occurrence of a simple fracture or contusion. It is not due to sepsis, but is produced by the absorption of *fibrin ferment*, a substance derived from blood-clot or the exudate from the injured tissues. Von Bergmann and others have shown by experiment that the injection of perfectly aseptic inert substances into the circulation, such as salt solution, finely powdered charcoal, pepsin, or even water, will produce an elevation of temperature. This fever is more apt to occur after operations in which a large amount of tissue has been divided with a considerable amount of oozing, as amputations of the larger limbs. Fibrin ferment has been obtained from defibrinated blood, and when much is injected into animals produces coagulation of the blood and death.

Symptoms.—Symptoms begin on the same day or the day following the operation, and consist in a slight rise of temperature, from 100° to 103° F., which usually subsides to the normal within three or four days. There are no other symptoms, except leucocytosis.

SEPTICÆMIA means septic matter in the blood, and is caused by the absorption of the products of saprophytic or pyogenic bacteria, or the entrance of pathogenic bacteria themselves into the circula-

tion. The varieties are *sapræmia*, or *septic intoxication*, and *septic infection*, or *true septicæmia*.

Sapræmia, or *septic intoxication*, is the result of the absorption of the toxins or ptomaines produced by the action of bacteria during the putrefaction of animal tissues. Some authors make a distinction between sapræmia and septic intoxication, the former being due to the absorption of toxins which result from the action of saprophytic bacteria, which produce decomposition, but are unable to propagate in the blood, while the latter is caused by the toxins produced in decomposing tissues by pyogenic bacteria. In both cases the cause is the absorption of toxins from decomposing animal tissues.

Symptoms.—The symptoms are elevation of temperature, chilly sensations, but not a severe chill. The temperature continues high, with flushed skin, rapid pulse, delirium with diarrhœa, and evidence of profound intoxication. Such symptoms result from the decomposition of blood-clots in poorly drained wounds, or from a retained putrid placenta. Death may result in a short time, but usually on removal of the decomposing material the temperature falls and all alarming symptoms disappear, as the toxin does not reproduce itself in the blood, as the living organisms do in septic infection or true septicæmia.

Septic infection, or *progressive septicæmia*, is caused by the entrance into the blood of pyogenic bacteria and their propagation there. Septicæmia is not caused by any special organism, but by any one of the pyogenic group which may enter the blood through the veins or lymphatics, by an open wound, from a mucous surface, or from infectious diseases, as erysipelas, scarlet fever, or osteomyelitis.

Pathology.—The post-mortem lesions are not characteristic. The blood is thin, of a dark color, with slight tendency to coagulation, and may contain numerous micro-organisms. Enlargement of the spleen and lymphatic glands and cloudy swelling of the liver and kidneys may be found.

Symptoms.—After infection a short period of incubation takes place, during which the bacteria multiply and produce ptomaines and toxins, the absorption of which gives rise to the symptoms. There is seldom a chill, but the temperature rises to 102° F. or 104° F. and is of the continuous type, possibly with slight morning remissions. In some cases of strangulated hernia and appendicitis the temperature is subnormal. The pulse is rapid and there is great prostration, with headache, loss of appetite, and typhoid-like symptoms. In bad cases the pulse grows weaker, the temperature higher (104° to 105° F.), with diarrhœa, delirium, and death in coma. Erythematous, pustular, or hemorrhagic eruptions may appear on the skin.

PYÆMIA.—Pyæmia is an infectious disease caused by the entrance into the blood of pyogenic organisms—usually the staphylococcus or streptococcus—and characterized by rigors, a febrile temperature, with *remissions*, *profuse sweats*, and the occurrence of *metastatic abscesses*. It was long thought that the disease was caused by the entrance of pus into the blood, but it is now known that the only causative action of the pus is to furnish the pyogenic organisms. It may be defined as a form of septicæmia characterized by thrombosis and metastatic abscesses.

Pathology.—The causes are the same as those given for the production of septicæmia, but, probably on account of the greater number and virulence of the invading bacteria, inflammation is set up in the walls of the veins which they enter, producing a thrombo-phlebitis. From the thrombi thus formed emboli are detached, and, entering the general circulation, find lodgement in the capillaries of the various organs,—the liver, lungs, kidney, or joints,—where they form metastatic abscesses. In their passage through the heart the infected emboli or the micro-organisms contained in them may produce endocarditis.

Symptoms.—If the result of an injury, the first symptoms appear in about ten days with a chill or high temperature, rapid pulse, furred tongue, and occasionally diarrhœa. The chill may be slight, but is usually severe, with a temperature of 103° to 106° F., followed by profuse *perspiration*. The temperature curve is characteristic, there being marked *remissions* or *intermissions* at irregular intervals. These exacerbations probably correspond to the formation of *metastatic abscesses*. Respiratory troubles may be noticed, due to the formation of abscesses in the lung or of effusion in the pleural cavity. A peculiar yellowish discoloration of the skin and a hay-like, sweetish, or purulent odor of the breath are often observed. The mind remains clear, except in some cases towards the end of the disease, when coma or delirium sets in. The cutaneous eruption described in septicæmia is sometimes seen in pyæmia. The disease may be acute or chronic; the acute cases die in a week or ten days, while the chronic cases may be prolonged for months and finally recover, or die from exhaustion.

Prognosis.—Most cases of the acute form die, but the prospect of recovery is greater in the chronic form.

TREATMENT OF TRAUMATIC FEVER, SEPTICÆMIA, AND PYÆMIA.—For aseptic fever no treatment is required except in the way of prevention during operations by arrest of hemorrhage and avoidance of dead spaces for the collection of blood. *Sapræmia* must be treated by removal of the decomposing tissue, clot, or other substances in which

the poison is contained. Septic wounds must be thoroughly cleansed with solution of bichloride 1 : 500 to 1 : 5000, or some other suitable antiseptic, and drainage provided. *Septicæmia* and *pyæmia* should be prevented by the practice of strict asepsis and antisepsis. Once established the source of septic matter should be sought and removed. If an abscess, open, drain, and disinfect if possible. Veins containing purulent thrombi must be excised or opened and drained. Sometimes it is necessary to open the lateral sinus and internal jugular vein on one or on both sides for the purpose of removing purulent thrombi following suppuration of the middle ear. Metastatic abscesses must be treated on general principles. *Constitutional treatment* consists in the free use of stimulants, as alcoholics and preparations of ammonia, and of heart tonics, especially strychnine and digitalis, with the administration of easily digested food and placing in good hygienic conditions. Salt solution intravenously and antistreptococcic serum have been used. The results from the use of antistreptococcic serum are conflicting and inconclusive. Recently the intravenous injection of very weak solutions of formaldehyde has been suggested and tried in cases of streptococcic septicæmia, but reliable conclusions are not yet possible.

CHAPTER XVI.

ERYSIPELAS.

ERYSIPELAS, OR ST. ANTHONY'S FIRE, is an acute infectious inflammation caused by the streptococcus erysipelatis. In pre-antiseptic days it was a not infrequent complication of wounds.

PATHOLOGY.—The cause of the disease is a chain coccus from three-tenths to four-tenths of a micromillimetre in diameter, probably identical with the streptococcus pyogenes. The organisms enter through wounds in the skin or mucous membrane which may be so slight as to escape notice, and spread in the lymphatic vessels and spaces, sometimes extending to the capillary blood-vessels and even to the veins. When conveyed to the lying-in woman the result is puerperal fever. Erysipelas seems to be more prevalent in the spring and fall.

SYMPTOMS.—The disease usually begins with a chill, sometimes with nausea or vomiting. For the first twenty-four hours no change about the wound may be noticed except, perhaps, a slight enlargement of the nearest lymphatic glands. The skin itches and burns and becomes red and œdematous. The redness has a well-marked, irregular outline and spreads in the direction of the lymph current. It may extend over a large area—*wandering erysipelas*, or may appear at a distant point—*metastatic erysipelas;* the parts affected in the beginning may become inflamed a second time. The color is dusky-red with a yellowish tinge, especially noticeable on pressure. The skin is swollen, brawny, with vesicles on the surface, wrinkles are effaced, and in facial erysipelas the eyelids are closed. Desquamation follows subsidence of the inflammation.

The constitutional symptoms are well marked, the temperature ranging from 102° to 104° F., with rapid pulse, coated tongue, headache, sometimes delirium, constipation, and excess of urates in the urine. The disease may last from one or two weeks to a month.

The *mucous membrane* of the nose, mouth, and throat may be affected. The tongue and tonsils become enormously swollen and œdema of the glottis or pneumonia may result. *Erysipelas neonatorum*, or erysipelas of the new-born, begins as an inflammation about the umbilicus, which may extend into the umbilical veins and produce phlebitis.

Phlegmonous erysipelas begins in the skin but extends to the sub-

cutaneous connective tissue. It occurs most frequently on the extremities in connection with ulcers. There is greater swelling, the skin is harder and thicker, and the constitutional symptoms more severe than in the ordinary form of the disease and it may assume a typhoid or septicæmic character. Suppuration is apt to occur, with extensive destruction of connective tissue and gangrene of the skin.

Erysipeloid is the name given by Rosenbach to a reticular lymphangeitis occurring in the skin of the fingers or hands of those who handle animal products—meat and fish. The cause is a special micro-organism supposed to be a mycelium-producing fungus. The disease begins with burning, itching, and redness of the finger, which gradually spreads to the dorsum or palm of the hand, seldom extending beyond the wrist. There is little fever, and the disease ends in from seven to fourteen days without desquamation.

Chronic ulcers, lupus, epithelioma, and lymphosarcoma have been known to recover after an attack of erysipelas, and toxins of the streptococcus have been used in the treatment of sarcoma.

COMPLICATIONS.—In the simple forms no serious complications are likely to occur. In phlegmonous erysipelas venous thrombi may form, with metastases, endocarditis, pericarditis, and abscesses in the lymphatic, parotid, or submaxillary glands. Infection of the orbit may produce suppurating thrombi in the sinuses of the brain. As a sequel there may be a chronic œdema ending in elephantiasis.

DIAGNOSIS.—In phlegmonous *cellulitis* the disease begins beneath the skin and the characteristic redness is not seen. By some no distinction is made between these two diseases.

PROGNOSIS.—The prognosis is good in *simple* erysipelas. In the other forms death may result from septicæmia, pyæmia, hemorrhage, œdema of the glottis, or pneumonia.

TREATMENT.—Supportive treatment is indicated, but a laxative may be given in the early stages of the disease. Tincture of chloride of iron in twenty-five drop doses every two hours, day and night, is thought to have an almost specific action. All precautions must be taken, by isolation and disinfection, to prevent the spread of the disease. The following local applications may be used: 25 per cent. ointment of ichthyol and lanolin; strong solution of acetate of aluminum; carbolic solution 1 to 20; or bichloride solution 1 to 1000. In phlegmonous erysipelas make incisions early to prevent gangrene. To prevent spreading various methods have been tried, as painting the skin in advance of the inflammation with collodion or iodine, scarifying a zone in the healthy skin and applying 1 to 20 carbolic acid or 1 to 1000 of bichloride to this scarified belt, and parenchymatous injections of carbolic acid.

CHAPTER XVII.

TETANUS, OR LOCKJAW, AND HYDROPHOBIA.

TETANUS.

Tetanus is an infectious disease caused by a special bacillus, which enters the tissues, probably in all cases through a wound. Here it produces toxins which, when absorbed, excite tonic spasms of the voluntary muscles which become aggravated by the slightest disturbance.

PATHOLOGY.—The bacillus of tetanus was discovered in 1885 by Nicolaier, and was obtained in pure culture in 1889 by Kitasato. It is an anaerobic, short rod, often enlarged at one end from containing a spore, so that it resembles a drumstick. It is motile, grows in

FIG. 72.—Tetanus bacilli.

chains, at ordinary temperature, in an atmosphere of hydrogen, in gelatin, which it liquefies. It takes all stains. The spores may be killed by five minutes' exposure to moist heat at a temperature of 100° C. (212° F.). The tetanus bacillus is found commonly in garden soil, in the dust of streets and dwellings, in old masonry, in the excrement of herbivora, and in putrefying fluids. Brieger isolated four toxins from cultures of tetanus bacillus, each of which produced

spasms, and one paralysis as well. The peculiar symptoms of the disease seem to be the result of the action of the toxins produced by the bacillus on the central nervous system, as the organism itself is usually found in the pus or tissues near the wound and rarely in the blood, nerve tissues, or internal organs. Punctured wounds are particularly liable to be followed by tetanus, because in the recesses of the wound the organism has the opportunity of growing without the presence of oxygen. Punctured wounds of the hands and feet are more likely to be followed by the disease simply because they are more apt to be soiled with the dirt which contains the organisms. Necropsies have sometimes shown small thrombi and exudation in the dura mater, degenerative changes in the brain, inflammatory changes in the cord and nerves, and evidence of ascending neuritis. The disease is said to be more common in tropical climates; in certain sections of the United States, as on Long Island; in the negro race, and after sudden falls in temperature.

VARIETIES.—Tetanus occurs in two forms,—*acute* and *chronic*.

SYMPTOMS.—*Acute Tetanus.*—After a period of incubation, usually one week, but which may be from one day to three or four weeks, the first symptom noticed is stiffness, with or without pain in the muscles of the jaws or neck, which the patient attributes to having taken cold. In a few hours there is difficulty in opening the mouth. About the same time the muscles of the face may become affected, causing the risus sardonicus. The spasms extend, involving the shoulders, back, and lower extremities, with opisthotonos. The muscles of the abdomen are also affected. The hands and forearms usually escape. Priapism is an occasional symptom. The spasms are tonic in character, but the slightest disturbance—a touch, a draught of air, or a loud noise—aggravates them. The heart and other muscles have been ruptured and bones fractured during them. The pulse is weak and rapid, the skin bathed in perspiration, and the temperature rises to 101° to 106° F., and sometimes continues to rise after death, reaching 104° to 113° F. The mind is clear, but the patient is anxious from pain and loss of sleep. Death may be sudden, from spasm of the heart or muscles of respiration, or gradual from exhaustion.

Chronic Tetanus.—In the chronic form the first symptoms appear gradually, and usually after a longer period of incubation than in the acute form. Contraction of the muscles of mastication (trismus) always occurs, and sometimes all the voluntary muscles are affected, as in the acute form, but the aggravated spasms are not as frequent nor as severe, and the patient does not suffer so much from exhaustion. The disease may last from six weeks to two months, or even longer.

Tetanus neonatorum, or *trismus nascentium*, is acute tetanus of the

new-born. It occurs in infants within the first week after birth, and is due to infection through the umbilical cord.

Tetanus hydrophobicus, or *head tetanus*, may be *acute* or *chronic*, and occurs after injuries of the regions supplied by the cranial nerves. There is usually paralysis of the facial nerve on the side of the injury, in addition to trismus and spasm of the pharyngeal muscles. Occasionally the muscles of the neck and abdomen are involved.

Puerperal Tetanus.—Tetanus occasionally occurs in puerperal women, and may be acute or chronic. It should not be mistaken for eclampsia.

DIAGNOSIS.—Tetanus must be distinguished from the following diseases: Inflammation of the temporomaxillary articulation, of the teeth, or of the cervical glands, and hysteria. In *strychnine poisoning* the spasms do not begin in the muscles of the jaw, but as general convulsions. In *tetany* the spasms affect chiefly the extremities, and can be produced by pressure on large arteries or nerves. It occurs after thyroidectomy, in dilatation of the stomach, chronic diarrhœa, rickets, etc. In *hydrophobia* the spasms occur in the throat only on attempting to swallow.

PROGNOSIS.—The mortality in acute tetanus is over 90 per cent.; in the chronic form it is much less. In children under ten years of age, in soldiers wounded in battle, and when its incubation period is less than one week, tetanus is especially fatal. Cases of acute tetanus usually die before the seventh day.

TREATMENT.—Prophylactic treatment is of the utmost importance. Punctured wounds should be laid open freely to the bottom and thoroughly disinfected. Chloral may be given in doses of from one hundred to two hundred grains daily until the spasms cease. Chloroform by inhalation is sometimes necessary, to give the patient rest. Amputation in tetanus is rarely if ever beneficial. Disinfection or excision of the wound may diminish the supply of toxins. Several cases have been reported as cured by intracranial subdural injections of tetanus antitoxin. The remedy should be given immediately after the first symptoms of the disease, or, better still, as a prophylactic before the symptoms begin. Subcutaneous injections of carbolic acid, ten to thirty drops of a 1 per cent. solution, every four hours, may be used (Baccelli). Sustain the strength with nutritious food by mouth or rectum.

HYDROPHOBIA, LYSSA, OR RABIES.

Hydrophobia is an acute infectious disease of the nervous system, caused by the inoculation of a specific virus from an animal afflicted with lyssa or rabies.

PATHOLOGY.—Rabies occurs most frequently in the carnivora,—the dog, wolf, fox, jackal, cat, and skunk,—but is sometimes seen in herbivorous animals, as the ox, horse, or sheep. It is said also to occur in swine, birds, and domestic poultry. The disease in man is always obtained by inoculation from an animal, usually by the bite of a dog. It has been estimated that only from 12 to 14 per cent. of those who are bitten by rabid animals develop the disease. The virus is contained not only in the saliva, but also in other fluids and tissues of the affected animal. Rabies in a dog may first show itself by unusual affection, and the animal may inoculate his master by licking his hand. Paroxysms of rage follow, alternating with dulness and restlessness. He wanders about with slinking aspect, red eyes, and foaming mouth, and if molested attacks the aggressor with uncontrollable fury, seizing anything, even a red-hot iron if presented to him, without evidence of pain. He does not avoid water, but drinks it eagerly. Paralysis follows the stage of excitement, and death usually occurs in from six to eight days.

The post-mortem lesions in hydrophobia are not well defined. Hyperæmia of the brain and upper part of the spinal cord and their membranes is usually found. Microscopical examination of the medulla oblongata and the spinal cord has shown lesions of an inflammatory character, distention of the minute vessels of the cord, with accumulations of leucocytes in the perivascular lymph sheaths. The mucous membrane of the alimentary tract is found congested, while the kidneys may give evidence of cloudy swelling.

SYMPTOMS.—(1) *The stage of incubation* is usually forty-two days, but may be as short as one day or as long as eight months. (2) *The premonitory stage*, lasting from one to three days, with pain or uneasiness in the wound, the scar of which may become irritable and congested; an uncontrollable feeling of depression or apprehension, with headache, loss of sleep and appetite; shooting pains from the seat of the wound or other parts of the body, or a general hyperæsthesia to currents of air and to light. The first well-marked symptoms appear as spasms of the muscles of deglutition and respiration whenever the patient attempts to swallow a liquid. (3) *The stage of excitement.* Paroxysms come on more frequently and are excited by the slightest disturbance of any kind. Swallowing is usually impossible, the mere suggestion bringing on a spasm. The mind is clear, though filled with excitement, anxiety, and terror, and hallucinations may occur. Mucus collects in the fauces, and the hoarse cough excited has been compared to a dog's bark. The temperature ranges from 100° to 103° F. (37.8° to 39.1° C.) and the pulse corresponds. This stage may last from thirty-six to seventy-two hours, ending in

death from exhaustion or asphyxia, or in the fourth stage. (4) *The stage of paralysis*, characterized by the remission of the spasm, but death results in from two to eighteen hours from a rapidly ascending paralysis, involving the heart or muscles of respiration. The entire duration of the illness is seldom longer than six days.

DIAGNOSIS.—In *tetanus* the spasms are tonic in character and begin in the back of the neck or the muscles of mastication, while in hydrophobia they are clonic and begin in the muscles of deglutition or of respiration. *Hysterical hydrophobia* resembles the genuine disease.

PROGNOSIS.—The disease is invariably fatal.

TREATMENT.—Give morphine and chloroform to relieve the pain and paroxysms, and enemata for thirst. The most important treatment is prophylaxis. Excise or lay open the wound and cauterize with nitric acid, and send the patient to the nearest Pasteur institute for treatment with emulsion of dried spinal cords. Cords from rabbits with hydrophobia that have been dried for various periods, from one to twelve days, are used, beginning with the one which has been dried twelve days, next day using one which has been dried ten days, and so on, until an emulsion of the fresh cord may be injected without harm.

CHAPTER XVIII.

GLANDERS, ANTHRAX, AND ACTINOMYCOSIS.

GLANDERS, EQUINIA, OR MALLEUS.

GLANDERS is an acute or chronic infectious disease, occasionally seen in man, and produced by the bacillus mallei. The bacillus mallei is a small rod, somewhat shorter and thicker than the tubercle bacillus, two to five micromillimetres long and five-tenths to one and four-tenths micromillimetres thick. It is facultative, anaerobic, non-motile, multiplies by segmentation and probably also by spores. It grows in the usual media, making white or yellowish thread-like colonies. It is destroyed by subjecting it for ten minutes to a heat of (131° F.) 55° C.

PATHOLOGY.—The disease is primarily one of horses, asses, and mules, in which it appears in two forms,—as *glanders*, acute or chronic, affecting chiefly the mucous membrane of the nose and other parts; and as *farcy*, acute or chronic, characterized by the appearance of nodules in the skin (farcy-buds), which are metastatic deposits. The horse probably receives the germ through the nose by inhalation. When it occurs in man it usually affects persons employed in the care of horses, infection taking place by contact of the nasal secretion of an affected animal with the mucous membranes or an abrasion of the skin. It may be transmitted from man to man. The bacillus produces a low grade of inflammation, resulting in granulation tissue, which, for want of the proper blood supply, soon breaks down, with the formation of pus and destruction of the tissues. In man the disease begins in the skin and subcutaneous cellular tissue, then extends to the mucous membrane of the nose and the respiratory tract, to the lungs and other organs, and is disseminated by the lymphatics and blood-vessels as metastases.

SYMPTOMS.—In the *acute* form the period of incubation is from three to eight days. At the point of inoculation a form of cellulitis of an erysipelatous character appears with lymphangeitis and swelling of the adjacent lymphatic glands. Vesicles form which may contain a bloody fluid, and later suppuration and gangrene may take place, producing a ragged, phagedenic ulcer. A wound which has healed may break open. If the mucous membrane of the nose be affected, ulcers form which spread and destroy bone as well as soft tissue. At

the same time general symptoms, as chill and elevation of temperature, occur. From one or two days to two or three weeks after the first symptons a general eruption of papules takes place in the skin. These become pustular, or hemorrhagic vesicles form. At the same time the mucous surfaces are affected in a similar manner; the eye, mouth, respiratory and alimentary tracts receive deposits of the virus, subsequent ulceration taking place with a mucopurulent discharge. From the general infection symptoms of pyæmia will appear, or in primary internal infection the disease may be mistaken for typhoid fever before the appearance of the external lesions. Death is the result of exhaustion.

DIAGNOSIS.—The disease must be distinguished from furuncle, carbuncle, lymphangeitis, erysipelas, rheumatism, and typhoid fever. Mallein may be used as a diagnostic test—like tuberculin in tuberculosis.

TREATMENT.—The prophylactic treatment consists in destroying animals afflicted with the disease and in thorough disinfection of the premises occupied by them. Isolate the patient. If the point of inoculation can be found before general infection takes place, remove it thoroughly and cauterize by the actual cautery or nitric acid. Open and disinfect nodules and abscesses. Give tonics and stimulants to support the patient's strength.

ANTHRAX, MALIGNANT PUSTULE, MALIGNANT CARBUNCLE, SPLENIC FEVER, OR WOOL-SORTERS' DISEASE.

Anthrax is an acute infectious disease caused by the entrance into the tissues of the bacillus anthracis—the largest of the known pathogenic microbes and one of the earliest discovered. It is aerobic, nonmotile, from five to ten micromillimetres long and one to one and one-fourth micromillimetres broad, occurs in the form of rods with square ends, and grows in chains, in most of the culture-media, liquefying gelatin, is destroyed by a temperature of 132° F., and in the bodies of living animals multiplies exclusively by segmentation, but under favorable conditions in other media it produces spores which are extremely resistant to the ordinary methods of sterilization. It is supposed to grow on plants, whence it is taken by herbivorous animals and develops in the mouth or intestine.

PATHOLOGY.—The disease affects animals in all parts of the world, especially Russia, Hungary, France, and Germany, where it often prevails as an epidemic, causing the death of large numbers of cattle and men. The animals most frequently affected are cows, sheep, and horses; donkeys, goats, and swine being less susceptible. Men contract the disease by handling hides, hair, and wool, inhaling the dried

spores or receiving them on abrasions, or by inoculation from the bites of insects. Post-mortem examination shows large numbers of the bacilli in the tissues about the pustules or carbuncles; in the liver, kidneys, and especially the spleen; also in the follicles of the stomach and intestines. The capillary vessels throughout the body may be almost blocked with the bacilli. The blood is thick and tarry, with no tendency to coagulate, and ulcerous or gangrenous patches are sometimes found on the mucous and serous membranes. Decomposition begins early in the cadaver.

FIG. 73.—Bacillus of anthrax.

SYMPTOMS.—The period of incubation is from one to three days, occasionally fourteen days. The disease occurs in two forms. *Anthrax carbuncle* occurs in dense vascular tissues and begins at the point of inoculation as a small red spot or papule, with an itching or burning sensation. In less than twenty-four hours a vesicle containing a brownish fluid forms, bursts, or dries into a brownish scab, with depressed centre, but no suppuration. A red inflammatory area surrounds the scab and a ring of secondary vesicles develops around the first. The vesicles may resemble those produced by vaccination. Swelling and infiltration follow, forming a *carbuncular tumor*, which may subside or become gangrenous and slough. *Anthrax œdema* occurs in loose connective tissue and appears with œdema, great swelling at the point of inoculation, livid skin, blebs filled with a bloody serum, and necrosis may occur in patches. In either form there is little pain, but lymphangeitis and phlebitis with the formation of septic thrombi, metastatic abscesses, and general infection may result. Otherwise the constitutional symptoms are perhaps merely chilly sensations and a rise of temperature to 100° or 101° F.

DIAGNOSIS.—Ordinary carbuncle is excluded by the depressed eschar, and the absence of suppuration, pain, and tenderness. The œdematous form must not be confounded with phlegmonous erysipelas or with malignant œdema. Bacteriological examination will confirm the diagnosis.

The PROGNOSIS is more unfavorable in the œdematous form, on

account of the greater liability to general infection; also, when the primary lesion is situated on the head or trunk. The mortality varies from five to twenty-five per cent. General infection is almost invariably fatal.

TREATMENT.—Remove the infected area before general infection takes place. In the *carbuncular* form excise the pustule or carbuncle. If this is done within the first forty-eight hours, general infection will often be prevented. In the *œdematous* form, when excision is impossible, make multiple incisions to relieve the tension of the congested tissues and dress antiseptically. Hypodermic injections of carbolic acid, strength 1 to 10, in the infected tissues and the margin of the healthy tissues may be made every six hours until the disease seems to be under control.

ACTINOMYCOSIS, RAY FUNGUS, OR LUMPY JAW.

Actinomycosis is a chronic infectious disease caused by the presence in the tissues of the ray fungus. To the naked eye the organisms appear as growths about the size of millet-seed. They are yellowish,

FIG. 74.—Actinomyces or ray fungus. (After Israel.)

sulphur-like bodies, with a soft unctuous but gritty feel. Under the microscope they appear as clusters of straight or wavy, branching threads, club or pear-shaped, radiating from a common centre. They are supposed to belong to the cladothrix variety of fungus, are stained by the ordinary solutions, and cultivated upon blood serum, gelatin, or agar.

PATHOLOGY.—In 1877 Böllinger first noticed the ray fungus in "lumpy-jawed" cattle. It has been found on rye and barley and probably enters the tissues of the animal through abrasions of the

mucous membrane. Here it excites proliferation of cells and the formation of granulation tissue in the jaws or other parts, with the production of tumors resembling sarcomata. On section such tumors show many soft, sulphur-yellow spots in the red tissue, and on microscopic examination these spots are found to consist of the ray fungus. Man contracts the disease, probably chiefly from infected grain, through the mouth and pharynx, sometimes the respiratory or intestinal tract, and occasionally the skin.

SYMPTOMS.—In man, as in cattle, the disease is most frequently observed in the lower jaw or some adjacent structure, as the mouth, tongue, or œsophagus, but any organ may be invaded. It first appears as a hard nodule of slow growth, and with little or no pain or signs of inflammation. The lymphatics are not involved, so that enlargement of the glands does not occur until after secondary infection, and if general infection takes place it is through the blood-vessels. The disease advances with formation of granulation tissue, which does not organize, but breaks down, with ulceration and suppuration. The pus resembles that from tuberculous abscesses, but contains the fungus. The progress of the infection is similar to that of malignant tumor, destroying all the tissues which it invades, infecting the veins, producing metastases and finally death from pyæmia. *Madura foot*, often seen in India, is a form of *actinomycosis*, in which the fungus invades the feet, causing caries and numerous sinuses, with the discharge of characteristic pus. Some authors claim that *Madura foot* is due to another fungus, the *Chionyphe Carteri*.

DIAGNOSIS.—*Actinomycosis* is easily distinguished from *sarcoma* and the *granulomata* resulting from syphilis and tuberculosis by the use of the microscope.

PROGNOSIS.—The prognosis is serious: many cases end fatally.

TREATMENT.—Remove the tumor, including all the infected area, as soon as possible, making the incisions well beyond the diseased area in the sound tissues. Open abscesses and excise the walls if possible. Inject a 1 to 20 solution of carbolic acid into tissues which cannot be removed. When the disease affects an extremity and thorough excision is impossible, amputate. Iodide of potassium, given internally in full doses, has a special curative effect on the disease.

CHAPTER XIX.

TUBERCULOSIS AND PLAGUE.

TUBERCULOSIS.

TUBERCULOSIS is an infectious disease caused by the bacillus tuberculosis, which may manifest itself by local infection or by general dissemination. Experiments showing the infectious nature of tuberculous material were made by Kortum in 1789, and by others, but the exact nature of the infectious agent was not understood until 1882, when Koch discovered the tubercle bacillus.

The tubercle bacillus is an aerobic, non-motile, slender rod, from two to six micromillimetres long (about one-half to one-third the diameter of a red blood-corpuscle), in breadth one-fifth to one-sixth of its length, usually straight, but may be slightly curved; grows singly, but sometimes in pairs or in bunches; generally beaded in appearance, from four to eight clear spots alternating with the stained parts; multiplies by fission and possibly by spore formation; stains with Gram's method or Ziehl's carbol-fuchsin solution; can be cultivated on blood serum or glycerin and gelatin at a temperature of (98° F.) 37° C.; and is easily killed by direct sunlight or by the ordinary antiseptic solutions.

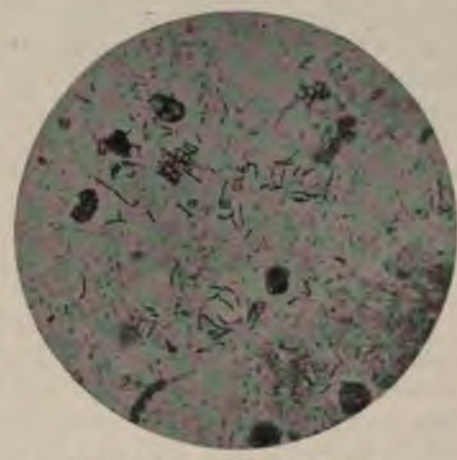


FIG. 75.—Tubercle bacilli in sputum.

PATHOLOGY.—Two varieties of tubercle are found in the tissues, —namely, the *gray* and the *yellow*,—the difference being due to fatty degeneration. Large masses are formed by the blending of several yellow tubercles. Under the microscope a tubercle is seen to consist of the following parts: (1) In the centre, one or more multiple nucleated giant cells; (2) outside the giant cells, usually large cells with big nuclei and granular protoplasm (epithelioid cells); and, (3) outside of these, a zone of lymphoid elements or leucocytes contained in a net-

work of fibrous tissue. The bacilli are found in the giant cells or between the epithelioid cells.

Certain *secondary changes* take place in tubercles,—namely, caseation, or coagulation necrosis, due to obliteration of the blood-vessels or to the special action of some substance produced by the bacilli. The change commences in the centre of the tubercle, where the bacilli are most numerous, and spreads towards the periphery. Fatty degeneration may proceed to disintegration, with the formation of abscess; or *calcification* may occur from the deposit of lime salts, and the tubercle is rendered inactive. On the other hand, the leucocytes in the periphery of a tubercle may develop and produce *fibroid* tissue, which imprisons the bacilli and keeps them inactive for an indefinite time.

Modes of Entrance into the Body.—The *tubercle bacillus* may pass from the mother to the child during fetal life (hereditary), but this rarely occurs. The inheritance of tissues especially favorable to the growth of the germ is probably more common. No doubt, in the majority of cases the germs enter through the respiratory passages by the inhalation of air containing dried sputum or pus from tuberculous patients. They may be conveyed by kissing, or the use of articles which have been used by a tuberculous patient; or in the milk of tuberculous cows, infected "rare" meat, or other contaminated food. In the intestine the bacillus is apt to locate in Peyer's patches. Slight wounds of the skin, as cuts, abrasions, or hang-nails, frequently form the avenues of entrance. Infectious diseases, as measles and scarlet fever, lower the vitality and render the individual more susceptible to invasion by the germs.

Means of Dissemination.—The bacilli extend from the tuberculous focus, first through the lymphatic system. They may be arrested in the lymphatic glands and cause swelling and abscess, or they may pass through and enter the venous circulation. A tuberculous thrombus may form in a vein, and from this infected emboli are widely disseminated and may involve any organ or tissue of the body. It has been estimated that from 15 to 20 per cent. of all deaths result from tuberculosis and it probably causes more work for the surgeon than any other infectious disease. No age is exempt, but it is more common in the young, especially in the bones, joints, and lymphatic glands.

Scrofula (from *scrofa*, a sow), or struma, is a name formerly given to tuberculosis of the cervical lymphatic glands. It is characterized by a peculiar appearance or type. A scrofulous child is usually a blonde, with pasty complexion, light hair and eyes, thick lips, large nostrils, dull expression, having a tendency to colds and chronic inflammation about the nose, eyes, ears, throat, and pulmo-

nary organs. By some, scrofula is thought to be caused by a special germ ; others regard it as a diathesis resulting from hereditary syphilis, or the general evidence of poor development and a weak constitution, caused by the lack of good hygienic conditions.

TUBERCULOSIS OF THE SKIN occurs in two forms, *lupus vulgaris* and *anatomical tubercle*. *Lupus* is seen most frequently in the young, on the face, but other portions of the body, particularly the extremities, may be affected. It first appears on the cheeks, nose, or some other part of the face, as a patch of small, soft papules of a reddish-brown color, lying just beneath the cuticle. The papules contain tubercle bacilli, and as they grow they may coalesce and form granular masses (lupus hypertrophicus) ; the process may extend by the formation of new papules or tubercles in the periphery, while healing takes place in the centre, with desquamation of the epidermis, leaving whitish cicatricial tissue (l. exfoliativus) ; or the tubercles break down, and ulceration may extend from one cheek to the other across the nose, to the conjunctiva or auditory canal, or to the mucous membrane of the mouth and nostrils, periosteum, and bone, causing fearful destruction, followed by mutilating contractions (l. exedens).

FIG. 76.—Lupus vulgaris.

Anatomical tubercle is the result of local infection in those who operate much on cadavers. It appears on the dorsal surface of the fingers or hands in the form of warts, which may be separate or in clusters or plaques, surrounded by an erythematous zone. Pustules sometimes develop. The growths are sensitive and may last for several years and produce general infection.

TUBERCULOSIS OF THE MUCOUS MEMBRANES, as of the mouth, nose, tongue, palate, tonsils, and pharynx, sometimes accompanies lupus. Tuberculosis of the rectal mucous membrane is the most common cause of fistula in ano. Tuberculosis may invade any portion of the genito-urinary tract. It may extend from the external organs to the Fallopian tubes and peritoneum, but usually begins in the Fallopian tubes or peritoneum.

TUBERCULOSIS OF THE LYMPHATIC GLANDS is common, either as a primary or secondary infection. The glands affected are, in order of frequency, cervical, cubital, axillary, and inguinal. Internally, the bronchial, mediastinal, and mesenteric glands are frequently affected, but these are scarcely amenable to surgical treatment. Infection of the cervical glands probably takes place through the mucous membranes of the nose and throat, either through a slight wound or as the result of a catarrhal inflammation. It occurs most frequently in persons between fifteen and thirty years of age. The micro-organisms multiply in the glands first affected, from which they are carried by the lymphatic vessels to the neighboring glands, which in turn affect others, until a chain may be formed, extending from the upper part of the neck to the sternum or into the chest. Acute miliary tuberculosis may result from invasion of the general circulation. The infected glands gradually enlarge, but are not painful nor tender to the touch. Fatty degeneration takes place with periadenitis, adhesion to the skin and adjacent tissues, ulceration, the discharge of pus, and sometimes a spontaneous cure.

TUBERCULOSIS OF THE BONES AND JOINTS.—*Tuberculosis of bone* is probably next in frequency to that of the lungs and lymphatic glands, and is most common in children and young adults. It may affect any bone or any part of a bone, but its favorite location in the long bones is near the diaphyso-epiphyseal junction. The bones most frequently affected are the vertebræ, femur, tarsus, carpus, humerus, scapula, ilium, tibia, ribs, and cranial bones. Tuberculosis of the bones is usually primary, infection occurring probably through the blood, which the bacilli enter by means of the respiratory or alimentary tract, or occasionally from an infected embolus, the result of primary tuberculosis in some other organ, as the lungs. The capillaries of the spongy ends of the long bones, being imperfect in structure, irregular in contour, with a slow circulation, are specially favorable for the lodgement and growth of the organism. If a terminal artery becomes obstructed by an embolus, the blood is cut off from the portion of bone which it supplies, and necrosis takes place, resulting in the formation of a pyramidal-shaped *sequestrum*, with its apex towards the obstruction in the vessel and its base towards the epiphyseal cartilage. Injuries are important in determining the location of the tuberculous process, slight injuries, as sprains and contusions, being more apt to be followed by the disease than injuries of a more severe character, as fractures. The presence of the bacilli or their ptomaines causes an excessive formation of embryonal or granulation tissue of low vitality, which, by pressure on the surrounding tissues, leads to their destruction, either by absorption

without the formation of pus or, if the process is very active, the granulation tissue (tubercle) breaks down and a "cold abscess" is formed, containing cheesy material, or thin pus with curdy masses, and sometimes pieces of bone. Should the inflammatory process be less active, an abnormal stimulus is given to the bone-producing tissues, and an excessive amount of bone is produced, filling up the Haversian canals and converting cancellous into compact bone,—*sclerosis* or *eburnation*. Bacilli may be imprisoned by this hardened bony tissue and remain dormant indefinitely, but are liable to renewed

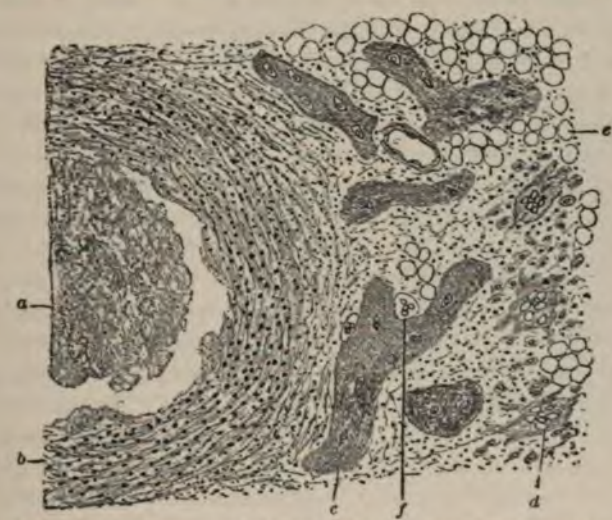


FIG. 77.—Tuberculous osteomyelitis of head of tibia: *a*, tuberculous abscess partly filled with thick pus and detritus; *b*, fibrous capsule formed around abscess; *c*, trabeculæ of bone; *d*, giant-cells in the bone marrow; *e*, fat-cells in the marrow; *f*, osteoclast causing absorption of bone. × 100 diameters. (F. C. Wood, M.D.)

activity from injury or other stimulus, and may revive the disease in the bone and possibly produce general dissemination. Pus may break into the joints or burrow through the connective tissue and form sinuses, which open on the surface in a bunch of fungous granulations. In the spongy bones, as the vertebræ, a dry caries with destruction of the bodies often takes place without the formation of pus. When the shaft of a long bone is affected *osteomyelitis* is produced. When this occurs in the phalanges the compact bone is destroyed, new porous bone takes its place, and the bone is enlarged in the middle, giving rise to the condition known as *spina ventosa*.

Tuberculosis of Joints.—This is known as *white swelling*, *tumor albus*, *strumous arthritis*, *chronic fungous arthritis*, *hip disease*, and *ankle disease*, and is the most common disease of the joints (Koenig). The

focus of infection may begin in the *synovial membrane* or in the bone. The primary focus is found in the bone about four times as often as in the synovial membrane (Mueller). Tuberculous granulation tissue forms in the synovial membrane, bone, and cartilage, and gradually extends to the surrounding ligaments, connective tissue, tendons, and muscles, giving them a gelatinous appearance. When these changes occur in the knee or elbow, the joint is spindle-shaped and the skin pale and waxy in appearance, hence the name *white swelling*. If the granulation breaks down, suppuration occurs, with destruction of cartilage and bone, and the abscess is apt to open externally, with the formation of sinuses. Under favorable conditions the process may cease and a bony or fibrous ankylosis result. In some cases destruction of tissue takes place without the formation of pus, so that the head of the bone disappears by absorption. This form of the disease is sometimes seen in the shoulder-joint, hip-joint, and vertebræ, and is known as *caries sicca*. When the inflammation results in the formation of fibrous masses beneath the synovial membranes, which subsequently project into the joint, or when the inner surface of the synovial membrane gives origin to pedunculated papillomatous growths, some of which become detached and remain free in the joint as "rice bodies" or "melon seeds," the process is called *tuberculous papillomatous synovitis*. When a large amount of granulation tissue is formed which involves the synovial membrane and periarticular structures, with a gelatinous appearance, it is known as *granulating fungous hyperplastic synovitis*. The joints most frequently affected are the hip, the knee, the ankle, and the elbow in children; the shoulder and wrist in adults.

THE DIAGNOSIS OF TUBERCULOSIS is determined by finding the tubercle bacilli in the sputum or discharges from the suspected organ, or by the elevation of temperature which follows the use of Koch's tuberculin.

PROGNOSIS.—The prognosis depends on the age of the patient, the organ affected, and whether the disease is local or general. General tuberculosis is always fatal. The prognosis is more favorable in children than in adults. If the disease is local and in a part which can be removed, the prognosis is favorable, although the liability to recurrence must be recognized.

TREATMENT.—Whenever possible the focus of infection should be removed by operation. This consists in the extirpation of lymphatic glands, the curettement or excision of diseased bones and joints, and occasionally amputation. (See Tuberculosis of special organs.) Lupus and other forms of tuberculosis of the skin may be treated by the application of pastes of arsenic or of salicylic acid with creasote;

by the use of the actual cautery to destroy the nodules; by puncture or scarification at frequent intervals; by electrolysis with the negative pole of a galvanic battery inserted into the nodules; by curetting with a sharp spoon and cauterizing with pure carbolic acid; and by dissecting away the diseased tissue and grafting healthy skin in its place according to Krause's method. Excellent results have been reported from the use of the Roentgen ray; also from the use of Finsen's ultraviolet rays.

PLAGUE.

Plague is one of the oldest diseases on record. It is an acute infectious disease caused by the entrance into the tissues of the plague bacillus, an organism discovered in 1894 by Kitasato and Yersin,—an aërobic non-motile cocco-bacillus, about two micromillimetres long and almost as broad. It stains with the ordinary dyes and decolorizes by Gram's method. It grows on the ordinary media, but does not liquefy gelatin.

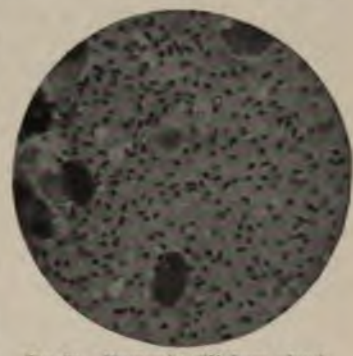


Fig. 78.—Plague bacilli from gland.

Varieties.—Plague is seen in three forms,—the bubonic, pneumonic, and septicæmic,—the bubonic form being the only one of surgical interest.

Symptoms.—The period of incubation is usually from two to four days. A small red spot may mark the point of infection, which becomes successively a vesicle and a pustule, and the advance of the infection along the lymphatics may be traced by red lines. The group of lymphatic glands nearest the point of entrance of the germs becomes enlarged, painful, and tender and matted together. The *diagnosis* is made by bacteriological examination of the pus from the buboes.

Treatment.—Yersin's antitoxin may be given, and no time should be lost in thoroughly excising the infected glands. Of 221 cases of bubonic plague treated by early excision there were 175 recoveries and 46 deaths. In cases with solitary buboes the results were still better, 145 operated on giving 120 cures and 23 deaths. (Reported from Rio de Janeiro, by A. A. Surgeon W. Havelburg, M. H. S.)

CHAPTER XX.

SYPHILIS AND CHANCROID.

SYPHILIS.

Synonyms.—Pox verole, morbus Gallicus, lues venerea.

Syphilis is a chronic disease, contagious in some of its stages, inoculable, transmissible by heredity, and, so far as is known, peculiar to man. The disease is probably caused by a micro-organism, and Lustgarten claims to have discovered it, but this is not accepted by the profession. Certain points, however, in its evolution so closely resemble diseases known to have a bacteriological origin that we are justified in placing it in the same class. Such are: The inflammation which occurs at the point of entrance of the virus, the *chancre;* the period of *incubation*, followed by *general symptoms*, fever, malaise, and pain, probably due to the *toxins* or *ptomaines* produced by the micro-organism; the various *eruptions* of the skin and mucous membranes, probably caused by local deposits of the virus or the microbe; and the *immunity* which exists against a second attack.

The course of syphilis may be divided into six periods, including the primary, secondary, and tertiary stages, two periods of incubation, and an intermediate period, in the following order: (1st) *The period of primary incubation*, the time which elapses between infection and the appearance of the chancre. This averages about three weeks, but may be from ten to sixty days. The extremes of the time given are one to ninety days. (2d) *The period of primary symptoms*, characterized by the appearance of the *chancre* and enlargement of the nearest *lymphatic glands.* (3d) *The period of secondary incubation*, which includes the time between the appearance of the chancre and the outbreak of *secondary symptoms*, on an average about six weeks, but it may be as short as four weeks or as long as four or five months. The *primary stage* includes the first three periods. (4th) *The period of secondary symptoms*, or *secondary stage*, or *constitutional syphilis*, which marks the appearance of *eruptions* on the skin and mucous membranes,—the syphilides,—general affection of the lymphatic glands, and lasts from one to three years. (5th) *The intermediate period*, or *latent period*, during which there may be no symptoms or only slight ones. This period is variable and may last from two to four years, ending in recovery, or in the (6th period) *tertiary stage*, which is characterized

by chronic inflammation and infiltration of the connective tissues with embryonal cells and the formation of gummata. This period is of uncertain duration.

ETIOLOGY.—The disease may be acquired in a perfectly innocent way—*syphilis insontium*. The *vehicles of the virus*, or of the *micro-organisms*, are (1) the secretion of the chancre; (2) the secretion of the secondary lesions, especially mucous patches; also of papules, pustules, or tubercles (the secretions from the tertiary lesions are generally admitted to be incapable of transmitting the virus); (3) the blood. The normal secretions—the sweat, saliva, tears, milk, spermatic fluid—do not communicate the disease.

The MODES OF TRANSMISSION of the disease are three: (1) Direct contact, as the sexual act, unnatural acts, kissing, nursing, circumcision, and skin-grafting. Surgeons and accoucheurs may acquire *syphilis insontium* by means of digital examinations. (2) *Indirect* or *mediate contact*, by means of articles contaminated with the virus, conveyed to an abrasion, or to the mouth, lips, gums, nose, eyelids, etc. (3) *Hereditary transmission*.

SYMPTOMS AND PATHOLOGY.—The first symptom of the disease is the appearance of the *chancre*, about three weeks after exposure, which always occurs at the point of inoculation. As Ricord says, "The patient is first punished where he has sinned." The chancre is found most frequently on the genital organs: in men, especially on the glans penis, fossa glandis, frænum, and inner surface of the prepuce; in women, most frequently on the labia majora, the fourchette, the labia minora, the surrounding skin, the neck of the uterus—rarely in the vagina. It appears as a superficial papule, abrasion, or ulcer, with sloping edges, scant secretion, and indurated base, the induration being due to a proliferation of cells and thickening of the tunica adventitia and intima of the small blood-vessels. The trabeculæ of the tissue are not destroyed. The thickening of the vascular walls without destruction of the connective-tissue supports gives the *hardness* so characteristic of the chancre, making it feel when taken between the thumb and finger as if it were a foreign body—"a split pea" or piece of cartilage—embedded in the skin. The chancre is usually *single*, and when multiple it is not the result of secondary inoculation, or autoinoculation, as all the chancres appear simultaneously. The *Hunterian* or *typical chancre* appears as a papule or erosion, which may slowly increase in size, is of a round or oval shape, of a brownish or bluish-red color, with a slight serous discharge; or it may be covered with a grayish slough. It has sloping edges and the characteristic feeling of cartilage embedded in the tissues. Many chancres do not present a typical appearance: the

mixed sore is often seen. A chancroid or any ulcer may be the atrium for the entrance of the syphilitic virus.

The DIAGNOSIS of chancre must be made from *chancroid*, *ulceration of herpes*, *epithelioma*, and, when concealed in the urethra, from *urethritis*. In *chancroid* there is no period of incubation. The ulcers may be said always to appear on the genital organs. They are usually two or more in number, with steep or undermined edges. The secretion is abundant and autoinoculable, so that secondary chancroids may appear from contact with it. The induration which may exist is of an inflammatory or œdematous character. The buboes are single, inflammatory, and apt to suppurate. *Herpes* appears as one or more groups of painful, small, superficial vesicles, which may return in successive crops. After ulceration the discharge is moderate; if induration exists it is inflammatory in character. Buboes are not usual, but if present are of the inflammatory variety. *Epithelioma* occurs usually on the lower lip, in males in the proportion of twenty to one, during or after middle age. It may be painful. In appearance it has a ragged irregular outline, not circumscribed, and is not influenced by syphilitic remedies. A chancre concealed in the urethra may be distinguished by the induration of the part and by examination with the urethroscope. *Confrontation*—that is, bringing forward for examination the person from whom the disease was obtained—is a valuable aid in diagnosis. It is usually impossible to make the diagnosis before the appearance of secondary symptoms.

The DURATION of chancre is variable,—from three weeks to as many months. It may last into the secondary stage, and in moist places may become converted into a mucous patch. If situated on the conjunctiva, in the meatus, or occurring in debilitated patients, loss of sight, stricture, or phagedæna may result.

SYPHILITIC BUBOES.—The bubo is an enlargement of the nearest group of lymphatic glands, caused by hypertrophy from the action of the syphilitic virus. The lymphatic vessels leading to the glands may also be affected. Buboes occur most frequently in the inguinal region, because the chancre is most frequently on the genital organs; but when it occurs on the lip, tongue, or eyelid, the bubo is found in the submaxillary or cervical glands. If it occur on the hand or nipple, the bubo is found at the elbow or in the axilla. The bubo can usually be detected in a week or ten days after the appearance of the chancre.

The syphilitic bubo may be recognized by the following symptoms: It always follows a chancre; it usually appears in both inguinal regions, especially if the chancre is on the frænum; several glands are

affected; they are painless, hard, separate one from another, with no tendency to fusion; they roll under the finger, are indolent, and have little tendency to suppuration. The effect of mercury is to cause their disappearance.

SECONDARY OR CONSTITUTIONAL SYPHILIS is the fourth period of the disease, being the result of the second period of incubation. It is characterized by peculiar eruptions of the skin and mucous membranes called *syphilides*. The time of their appearance averages six weeks after the appearance of the chancre, though it may be four weeks or four or five months, the shortest time recorded being twelve days and the longest two hundred days. Coincident with, or previous to, the appearance of the eruption, there is a general hypertrophy of the glands of the lymphatic system. This may be detected in the epitrochlear gland just above the internal condyle of the humerus, or in the postcervical or submaxillary glands, the enlargement being symmetrical. Other constitutional symptoms are fever, lasting three or four days, with a temperature of 100° or 102° F.; headache, loss of appetite, and malaise; *pains* in the muscles and joints, like rheumatism. Within a few days the characteristic *eruption* appears, first in the throat, then on the skin; the patient may complain of sore throat. There are anæmia and marked *leucocytosis*, with diminution of red blood-corpuscles and oxyhæmoglobin. *Alopecia* may occur soon after the appearance of the secondary symptoms or at a later period of the disease. Not only the hair of the scalp, but that of the entire body may be lost, but it usually returns. The appearance of the syphilides may be retarded by the administration of mercury. *The early syphilides* are superficial, affecting only the papillary and epidermic layers of the skin, growing deeper as they grow older, the later forms involving the deep cutaneous and subcutaneous layers in addition.

Syphilides are *classified* by Cornil as follows: (1) Erythematous—erythema, macules, roseola. (2) Papular—conical, lichen-like, large papules, papulolenticular and papulosquamous. (3) Pustular—acneiform, impetiginous, ecthymatous, and rupial. (4) Vesicular—these may be included under the papular or pustular syphilides. (5) Gummatous or tubercular—which belong to the tertiary stage of the disease.

Characteristics of the Syphilides.—They are *polymorphous*—many forms of eruption occurring at the same time, as erythema with papules and pustules; the *color* resembles that of copper or ham and is due to the extravasation of the red blood-corpuscles in the skin; the *shape* tends to circles, segments of circles, or figures-of-8—probably due to the distribution of the cutaneous capillaries; there is no

itching or *pain;* and they are *symmetrical*, appearing on both sides of the body.

The *erythematous syphilide*, in the form of erythema, macules, or roseola, is usually the first to appear and may be detected on the mucous membrane of the throat before it appears on the abdomen, whence it spreads to the chest and extremities. *The papular eruption* may be the first to appear, but usually follows the macular. It occurs in two forms,—the *small*, or the lichen-like or miliary papule, and the *large* papule. It varies in size from a pin-head to that of the finger-nail, or even larger, and projects slightly above the surface of the skin. It forms the basis of most of the secondary eruptions, as the papulo-squamous, the mucous patch, and the pustular forms.

The HISTOLOGY consists in hypertrophy of the papillæ of the skin. In some cases there is a considerable increase of the epithelial layers above, giving rise to the papulosquamous variety. When the epithelial layers become softened or worn away, the papillæ are much hypertrophied and project above the surface and form *mucous patches*.

FIG. 79.—Rupia affecting the head, trunk, and extremities.

If suppuration takes place beneath the epidermis covering the papillæ, *syphilitic acne* is the result. If the suppuration advance a little further, with the formation of crusts, it is called *impetigo*. A still further degree of suppuration with destruction of the epidermis, or even of the skin itself, produces *ecthyma* or *rupia*. The small variety is found on the scalp and on the body, and the papulosquamous on the palms of the hands and soles of the feet, where, from the amount of scaliness produced, they are often called *syphilitic psoriasis*. The *papulotubercular syphilide* is also found on the shoulders, neck, trunk, and face, where it forms elevated patches or bands, striking in appearance. The duration is from two or three weeks to as many months.

RUPIA (dirt) is pathognomonic of syphilis. It may occur in the late secondary or in the tertiary stage. It appears in the form of large pustules filled with turbid or blood-stained pus. It soon dries at the top; ulceration around the edges of this crust takes place, and another layer of pus dries, forming a larger scab beneath the first, and so on, until a conical pile of imbricated scales

of a greenish or dark-brown color is formed. The lesions vary in size from half an inch to two inches in diameter, and may project a quarter of an inch above the surface.

IRITIS may occur in the secondary or tertiary stages. *Simple plastic iritis* usually occurs from the second to the ninth month, while *gummatous iritis* appears in the late secondary or in the tertiary stage.

TERTIARY SYPHILIS, or the tertiary stage, is the sixth and last period in the course of the disease, and follows the intermediate period. It may come on from two to four years after the beginning of the intermediate period or at a much later date. It is characterized by chronic inflammation of the connective tissues, including the bones and periosteum, with infiltration of embryonic cells, which accumulate in certain organs and form small swellings called *gummata*. It may be regarded as the result of the damage done during the first and second stages. According to Haslund, tertiary syphilis may be expected to occur in twelve per cent. of all cases.

The syphilides of the tertiary stage are the *rupial*, *tubercular*, and *gummatous*. The *rupial* has already been described. *The tubercular syphilide* may be considered as the transition stage between the papule and the gumma. It is in groups or solitary, and may disappear by absorption, leaving a pigmented spot, or ulcerate with suppuration and destruction of the skin. *The gumma*, or *infectious granuloma*, occurs in the form of nodules from the size of a pea to that of a walnut, in the connective tissue of the skin, subcutaneous tissue, brain, spinal cord, or any other organ. It usually develops three or four years after the initial lesion, but may occur as early as five months from the beginning or as late as twenty years. It is the most characteristic lesion of tertiary syphilis. Histologically, a *gumma* is a circumscribed infiltration of the connective tissue with embryonic cells. The gumma usually begins *beneath* the surface as a painless swelling or nodule, which gives no trouble except by its presence. It grows slowly, but finally degeneration takes place with softening, it becomes adherent to the skin or mucous membrane, which ulcerates, and the contents of the gumma—a purulent or gummy liquid—are discharged. Repair then takes place with a depressed cicatrix.

TERTIARY SYPHILIS OF SPECIAL ORGANS AND REGIONS.—*The Mouth.*—Late in the disease a form of *mucous patch* sometimes occurs on the mucous membrane of the cheek or tongue, and is known as *leukokeratosis*, and may form the site for the development of a malignant growth. *Gummata* may appear in the *tongue*, either deep in the muscles or just beneath the dorsal mucous membrane; also in the soft or hard palate, which may be perforated.

Muscles.—A *diffuse infiltration* (myositis) may occur in the muscles, as the biceps, tongue, muscles of the neck, diaphragm, and heart.

Syphilis of the testicles may occur as an *interstitial orchitis* of one or both sides, or as *gummata* of the *epididymis*.

Respiratory Tract.—Gummata may cause ulceration of the larynx. The ulcer is usually solitary, deep, round, or oval in shape and, if on the epiglottis, occurs on its upper surface.

The Nervous System.—Gummatous tumors, sclerosis, or obliterating endarteritis may develop in the brain or spinal cord and give rise to characteristic symptoms.

Bones.—The bones may be affected either in the secondary or tertiary stage. The exciting cause is often a slight traumatism, so that the bones most frequently affected are those exposed to such injuries, as the frontal bone, clavicle, sternum, radius, and tibia.

Histology.—There is a proliferation of round cells of the embryonic type in the Haversian and medullary canals, which cause erosion or absorption of the bone elements and enlargement of the spaces in the bones—spina ventosa. (See TUBERCULOSIS OF BONES.) If the inflammation is slower and less intense, an excessive amount of new bone is produced, increasing the laminæ until the Haversian canals become obliterated. The medullary cavity may also be obliterated, and a heavy, solid condition of the bone result, known as *sclerosis* or *eburnation*. The development of *gummata* in the subperiosteal or medullary tissues produces the most intense form of *syphilitic osteomyelitis*, with destruction of bone and the formation of sequestra.

DACTYLITIS is a gummatous inflammation of the phalanges occurring during the late secondary or tertiary stages. It may involve

FIG. 80.—Syphilitic dactylitis.

chiefly the fibrous and integumentary tissues surrounding a joint, or it may include the periosteum and bone. There is little pain, but the joint may be destroyed.

HEREDITARY SYPHILIS is contracted *in utero*. The disease may reach the child in one of three ways: First, through the father by means of infected spermatozoa; second, through the mother by means

of an infected ovum; third, at a later period of intra-uterine life through the uteroplacental circulation. If the mother have active syphilis, she is almost certain to transmit it to the child, up to the seventh month; after this period transmission is not so likely to occur. During birth the child *may* be directly infected by coming in contact with contagious lesions, such as mucous patches, but no such case has ever been recorded. The protection given by the mucus and vernix caseosa is not sufficient to account for this exemption, the true explanation being that the child is immune to the disease, having had a modified form of syphilis before birth. It may be born healthy and remain so, but it is protected from the disease, as has been proved by experiment and subsequent experience on exposure. This is Profeta's law. The converse of this is Colles's and Baume's law, that a child having all the evidences of syphilis may be born of an apparently healthy mother, and, although attended by the mother and nursed by her, fail to give her the disease, but if nursed by any one else, as a wet-nurse, the latter is almost sure to contract the disease, showing that the mother of the affected child is in some manner protected. The explanation is that the mother is protected or immunized, having acquired a modified form of syphilis from the child during pregnancy. According to Hutchinson, parents in the late tertiary stages do not transmit taint, and Fournier's opinion, from an experience of many hundreds of cases, is that in the case of paternal heredity he has never known it to extend beyond three or four years; so that we may consider syphilis a self-limited disease, so far as its contagion and transmission are concerned, that even when permitted to run its course *without* treatment it cannot be transmitted after three or four years, and *with* proper treatment this time is probably considerably shortened.

Stages.—Hereditary syphilis has only two stages, the secondary and the tertiary.

Symptoms.—The child at birth has an atrophied appearance, a wrinkled, withered face, a "wise old man" look, a hoarse cry, coryza or snuffles, and *pemphigus* on the palms and soles, sometimes on the limbs. If there are no symptoms at birth, roseola may be the first symptom, about the second or third week, then *mucous patches* on the tongue, lips, cheeks, and anal region, and after the sixth week the pustular syphilides. The liver and spleen are frequently much enlarged. Lesions of the tertiary stage appear soon after, or may be commingled with, those of the secondary stage. The disease lasts from twelve to eighteen months, after which there are no symptoms, unless the third stage appears. Tertiary syphilis is apt to manifest itself about the period of second dentition or of puberty. The *ear* is

often involved,—external, middle, or internal,—and sudden deafness may develop; the *eyes* may be affected in the form of *keratitis*, and the permanent teeth furnish the most important evidence of the disease, —"Hutchinson's teeth." The upper median incisors are stunted, short, "pegged," and often widely separated. The cutting edge is narrow, crescentic (not serrated), and sometimes projects forward rather than downward. There is sometimes a collar-like enlargement at the diaphyso-epiphyseal junction of the long bones.

PROGNOSIS.—The prognosis in hereditary syphilis is much more unfavorable than in the acquired form. About one-fourth die within the first six months. If they survive this period the chances are slightly in their favor. The prognosis is more favorable when the first symptoms of the disease appear after six months.

TREATMENT.—Treatment may be divided into prophylactic and curative. *Prophylactic treatment* relates to the prevention of the hereditary form of the disease by advice as to the proper time for marriage and the prevention of the acquired form by excision of the chancre in cases which seem suitable. The patient should be given to understand that treatment is necessary over a period of from two and a half to three years. Consent to the marriage of a person affected with syphilis should not be given usually until after the lapse of three or four years from the beginning of the symptoms, and under no circumstances until at least six months after the last appearance of any of the phenomena of the disease. *Excision* of the *chancre* as soon as it appears, and in some cases of the *enlarged inguinal glands*, has been practised, on the theory that the virus or microbes were limited to these parts, not yet having entered the general system; but the results have not been encouraging.

Curative Treatment.—The indications are, first, to *destroy* the *virus* or to neutralize its effects on the tissues; second, to *sustain* the *strength* of the patient and treat the anæmia which usually occurs during the prolonged course of the disease. *Mercury* and *iodide of potassium* are considered specifics in the treatment of syphilis. On account of the danger of salivation, the inconvenience of a prolonged course of treatment, and the possibility of retarding the appearance of the secondary symptoms and obscuring the diagnosis, the administration of mercury should not begin until a *positive* diagnosis has been made,—that is, until the appearance of symptoms of the *secondary stage*. Mercury seems to act by causing disintegration of the products of the disease, while iodide of potassium aids its elimination; hence, mercury is given in the early stages and iodide of potassium later. In the later stages some give a mixed treatment of mercury and iodide of potassium. Mercury seems also to act as a tonic, thereby counter-

acting the anæmia which occurs so frequently, and as a *physiological antidote* to the syphilitic poison, possibly as a germicide. It may be given by the *stomach*, by *inunction*, by *fumigation*, by *hypodermatic injection*, and by *intravenous injection*. The preparations of mercury most frequently used are the protiodide, bichloride, calomel, gray powder, blue pill, and the ointment of mercury. The *protiodide* is given in pill form, in doses of $\frac{1}{6}$ to $\frac{1}{4}$ of a grain three or four times daily. For irritation of the stomach or bowels it may be combined with opium, $\frac{1}{20}$ or $\frac{1}{10}$ of a grain to each pill. Corrosive sublimate may be given in doses of $\frac{1}{10}$ to $\frac{1}{15}$ of a grain, in combination with compound tincture of cinchona; and gray powder in $\frac{1}{4}$ to 1 grain doses, three or four times daily, combining it with Dover's powder, if necessary, to prevent diarrhœa. By *inunction*, 1 drachm of the unguentum hydrargyri is rubbed into the skin daily for a month or six weeks. In young children it may be used in the proportion of 1 to 8, applied on a flannel bandage. *Fumigation* is used in the treatment of obstinate eruptions or where a quick result is desired, by vaporizing calomel under the patient seated naked on a chair and covered with a blanket. *Hypodermatic injections* are open to the objection of being very painful and sometimes producing abscesses. A good formula is: Bichloride of mercury, 32 grains; chloride of ammonium, 16 grains; and distilled water, 2 ounces. Ten minims are injected through a platino-iridium needle, in the gluteal region, once a week for six or seven weeks, and then at longer intervals (Cooper). *Intravenous injections* of 20 minims of a 1 per cent. solution of cyanide of mercury every other day, or daily, are recommended by Lane. In using mercury the *dose* for each individual has to be found by trial. A good way is to give the patient a small dose, say one-sixth of a grain of the protiodide three times a day, gradually increasing it until slight soreness of the teeth is felt. Then diminish the dose one-half or one-third, and continue for two years, omitting every third month. Avoid salivation. Iodide of potassium is given in doses of 5 to 20 grains, but in syphilis of the nervous system, with gummata in the brain, large doses gradually increased to as much as an ounce in twenty-four hours have been given with decided benefit. After treatment with the iodide of potassium for six months keep the patient under observation six months longer, when, if no symptoms have appeared, he may be pronounced in all probability cured. Tonic and supportive treatment is often necessary in the form of cod-liver oil or bitter tonics. Hot baths and the drinking of hot water, as practised at certain hot springs, are advantageous in stimulating the emunctory organs, thereby enabling the patient to take larger doses of mercury and iodide of potassium.

The *local treatment* of the *chancre* consists in the use of some non-irritating powder or ointment, as iodoform, aristol, calomel, or bismuth. *Mucous patches* and *ulcerative lesions* should be treated with antiseptics, silver nitrate, black wash, and drying powders.

The contagiousness of the disease and the necessity of guarding against its communication to others must be impressed upon the patient.

Dr. Edward Cotterell, of England, used the blood serum of those who had just passed through an attack of the disease in eighteen cases with decided benefit.

CHANCROID.

Chancroid, soft chancre, or simple venereal ulcer, was considered, previous to the adoption of the dual theory about 1852, one of the manifestations of syphilis. It is a local disease without general infection, so far as known.

The ETIOLOGY of chancroid is not settled. It is thought by many to be the result of infection with any of the pyogenic bacteria, by others that it is due to a special organism—among them Ducrey's streptobacillus. Chancroid appears in the same localities as chancre. It is more common in free hospital and dispensary practice and among the lower classes than in private practice among well-to-do-patients. Sturgis gives, in 13,572 venereal sores, 10,337 cases of chancroid and 3,235 of chancre.

FIG. 81.—Phimosis from chancroids.

THE MODE OF ACQUISITION is direct, as in coitus; or indirect, occasionally, from contact with towels, clothing, etc., contaminated with the poison.

SYMPTOMS.—There is no period of incubation, although the lesion may not be noticed until the third or fourth day of its existence. It begins as a red point, which passes through the stages of papule and pustule to ulceration within three days. The ulcer has a decided tendency to spread and destroy tissue, and is round, oval, or irregular in shape, with precipitate or undermined, sometimes ragged, edges, rough bottom covered with a grayish deposit, and a purulent and sometimes bloody discharge. Pain and soreness are usually felt.

There is an inflammatory, swollen, boggy condition of the parts, gradually merging into the healthy tissues, in contrast with the hard, sharply-limited sensation of a foreign body in the parts, so characteristic of chancre. The microscope shows infiltration with small round cells which destroy or soften the connective-tissue trabeculæ. In number chancroids are usually multiple. They may be multiple from the beginning, or become so by autoinoculation,—inoculation of healthy skin with pus from the first sore,—intentionally or accidentally, producing sores similar to the first.

DURATION.—Ordinary cases recover in five or six weeks; if complicated with buboes or phagedæna the disease or complication may continue six months or longer.

COMPLICATIONS.—These are: Bubo, phagedæna, gangrene, phimósis, and paraphimosis. *Bubo* occurs in from fifty to seventy-five per cent. of all the cases, and usually suppurates. While the bubo is generally unilateral, it is not infrequently bilateral. No micro-organisms have been found in the contents of these buboes, but they are supposed to be due to micro-organisms or to toxins which come from the chancroid. *Phagedæna* may affect the chancroid or an open bubo, and is characterized by a rapid, relentless spread of the ulceration,—the entire penis being sometimes destroyed or the testicles or abdominal muscles laid bare. The *cause* is supposed to be a germ or toxin (unknown) or some dyscrasia.

TREATMENT.—If seen early—before infection of the lymphatics—excision with the knife or scissors and suture of the wound may be tried. Otherwise aim to get cleanliness without irritation,—using bichloride 1–5000, twice daily, followed by the application of iodoform powder or salve, aristol, bismuth subgallate or subnitrate, calomel, or oxide of zinc. Place a thin layer of absorbent cotton between the sore and the prepuce or glans. *Phimosis* or *paraphimosis* requires slitting up of the prepuce. The *bubo* should be excised at its earliest appearance, before suppuration, the wound closed, and the patient kept in bed. If suppuration has occurred, use hot applications till the entire gland is broken down; evacuate the pus through a small incision, wash out the cavity with bichloride 1–3000, and fill with iodoform emulsion, ten per cent. in glycerin or warm vaseline, and apply a compress to prevent its escape. If this fail, open freely, curette, and pack with iodoform gauze. The deep lymphatic glands along the iliac vessels may require removal. This may be done by the incision used for ligating the external iliac extraperitoneally. *Phagedæna* should be treated by thorough excision or cauterization with nitric acid, then simple antiseptic dressings, iodoform, solution of bichloride, tonics, and good hygiene.

CHAPTER XXI.

TUMORS AND CYSTS.

TUMOR means swelling,—an atypical new formation not the result of inflammation (Green). It is a new growth, or neoplasm, which produces a localized enlargement of an organ, having no useful function, no tendency to spontaneous cure, is uninfluenced by drugs, and tends to grow through the life of the individual.

ORIGIN.—All tumors come from pre-existing tissues,—that is, every tumor cell has its physiological prototype. The majority originate from connective tissue (histoid tumors), or from epithelium, surface or glandular (organoid tumors). *Homologous tumors* are composed of the same kind of tissue as that in which they originate. They are usually benign. *Heterologous tumors* contain different tissue from that in which they originate. They are often malignant. *A fibrous tumor* originating in the subcutaneous connective tissue is an example of *homologous* tumor; while a cartilaginous tumor originating in the parotid gland is an example of a *heterologous* tumor. *Heterotopic* is the term applied to tumors which contain tissue different from that in which they are *situated*. This may be due to extension of the tissues composing a tumor beyond their normal limit or to metastasis.

According to their relation to surrounding tissues, tumors are encapsulated or non-encapsulated. An *encapsulated tumor* is separated from the surrounding tissues by a fibrous capsule which envelops it. A *non-encapsulated* tumor has no limiting capsule and the tissues of the tumor invade and penetrate to a variable degree the surrounding structures.

CHANGES IN TUMORS.—The tumor rarely disappears, but sooner or later becomes the seat of retrogressive changes, as *fatty degeneration* with softening or caseation, or *pigmentary*, *calcareous*, *mucoid*, or *colloid* changes. *Inflammation*, *ulceration*, and *necrosis* with *hemorrhage* may take place. On the other hand, *developmental* changes may take place by which the lower or embryonic tissues of the tumor develop more or less completely into the higher tissues, as in the formation of fibrous or bony tissue from the embryonic cells in a sarcoma. The more embryonic the tissue composing a tumor and the more rapid its growth, the sooner it degenerates and the more malignant it is likely to be. Sarcoma is a good example.

CLINICAL COURSE.—According to their clinical course tumors are divided into two great classes, *benign* and *malignant*. *A benign tumor* grows slowly or remains stationary. It is composed of tissue closely resembling some normal adult tissue and similar to that from which it originates—*homologous*. It is usually *encapsulated*. The *blood supply* is small. The adjacent *lymphatics* are not affected; it is *painless;* if removed it does *not recur*, and the health of the individual is not materially affected, unless on account of mechanical interference. *A malignant tumor* grows rapidly, with a constant tendency to involve *adjacent* structures. It is composed of atypical tissue, often differing widely from that in which it originates or in which it is found—*heterologous* and *heterotopic*. Not being *encapsulated*, it invades all the surrounding tissues, even bone, soon becoming fixed and more or less immovable. The *blood supply* is large; the *lymphatics* are usually affected; *pain* is usually present; if removed it tends to *recur* locally; the *health* of the individual is materially affected,—an anæmic condition or cachexia resulting, due to pain, anxiety, or possibly poisoning from a toxin produced by the tumor.

Removal of a malignant tumor may be followed by reproduction, *local*, *regional*, or *general*.

Local reproduction is caused by the extension of the cells to the connective-tissue spaces surrounding the tumor. This is the earliest and least important evidence of malignancy. *Regional reproduction* is due to infection of the nearest lymphatic glands to which the tumor cells are conveyed by means of the lymph-vessels. *General reproduction*, or *generalization*, is due to the entry of the malignant cells into the blood stream, either directly or by way of the lymphatics, causing emboli which form new foci of infection in the organs in which they lodge. Extension may take place in other ways as a result of gravity, as infection of the lungs from a tumor in the trachea, or the bladder from the kidneys through the ureters. The "juice" of a tumor probably plays no part in its reproduction, the active agents being the cells, as secondary growths have never been found in the structures into whose circulation cells cannot enter, as in the cornea and cartilage. There are two views as to the manner in which the migrated cells produce secondary growths: *First*, that of "spermatic influence," according to which the impacted cells of an embolism impress their character on the cells of the vessel walls and surrounding tissues with which they come in contact, causing them to multiply and produce cells similar to those of the infected particle; *second*, that the secondary growth is due to the multiplication of the cells contained in the embolus alone. This is probably the correct view.

ETIOLOGY.—*Age.*—*Connective-tissue* tumors are more common previous to middle life, while these tissues are most active; while *epithelial* tumors are more frequent in later life, during the period of relative greatest epithelial activity. *Race.*—Keloid and fibromyoma seem to be more frequent in the negro race. *Sex.*—Epithelioma of the lip or tongue is more frequent in males, and tumors of the breast in females. *Heredity.*—While the germ of the tumor may not be inherited, in all probability a diminished resistance or tendency to the production of tumors when favorable conditions arise, may be transmitted. *Physiological activity,* as in *adenoma* of the breast, or cysts of the ovary. *Cohnheim's theory* of "embryonic remains."—This theory assumes that in the development of the embryo more cells for some particular tissue are produced than are needed and the surplus remain in an embryonic state, either in one spot as "resting spores" or scattered over the whole tissue. At a later period, as a result of physiological activity or the stimulus of injury, these cells are excited to growth and form a tumor. In support of this theory are chondroma of the parotid gland and the frequent occurrence of tumors where the developmental processes are complicated, as at the mucocutaneous openings. The *parasitic theory* is not generally accepted. It attributes the cause to an animal parasite belonging to the order of the protozoa. The reasons are: The resemblance of cancer to lupus; its contagiousness; the antagonism between cancer and active tuberculosis and malaria, and between sarcoma and erysipelas; and that parasites in emboli would explain metastases. *Injury* or *irritation*—as the occurrence of sarcoma after fractures; of tumors of the lip or tongue from irritation of a cigar, pipe-stem, or bad teeth; or their development at constricted points, as at the pylorus, the ileocæcal valve, and rectum. *Malignancy* may be explained by the theory of "physiological resistance" (Cohnheim), which means the normal resistance that prevents one tissue from encroaching on or invading another though lying in contact and growing side by side with it; for example, the epithelial layers of the skin and the connective-tissue layers grow in harmony, neither invading the domain of the other, so long as normal conditions prevail. Injury or age may destroy this armed neutrality and the weaker tissue is then invaded by the stronger. Before middle age the connective tissues are stronger and more vigorous, and this is the time when connective-tissue tumors, sarcomata and others, most frequently occur. After middle age the epithelial tissues prevail over the diminishing connective tissues, and this period of life is characterized usually by tumors of the epithelial type.

CLASSIFICATION OF TUMORS.—Tumors are perhaps best classified

according to their *origin and histological* structure. Some originate from the mesoblast, others from the epiblast and hypoblast, and still others from all three,—mesoblast, epiblast, and hypoblast. See the following table, modified from Green.

A. Mesoblast

I. Type of higher tissues:
- Myoma,
- Neuroma,
- Angioma,
- Lymphangioma.

II. Type of *fully* developed connective tissues:
- Fibroma,
- Lipoma,
- Chondroma,
- Osteoma,
- Lymphoma,
- Odontoma,
- Myxoma.

III. Type of *embryonic* connective tissue:
- Sarcoma.

IV. Not classed—transition between sarcoma and carcinoma:
- Endothelioma.

B. Epiblast and hypoblast

V. Type of epithelial tissues.

1. Of high development:
   - Papilloma,
   - Adenoma,
   - Cystoma.

2. Of *low* development:
   - Carcinoma { Round cell, hard; Soft; Colloid. } Glandd.
   - Epithelioma { Flat or squamous cell; Cylindrical. } Surface.

C. Epiblast, mesoblast, and hypoblast

VI. Teratoma.

A. MESOBLASTIC OR CONNECTIVE-TISSUE TUMORS.

I. Type of Higher Tissues.—These are benign tumors.

MYOMATA, or MUSCLE TUMORS, are of two kinds, the *rhabdomyoma*, containing striated, and the *leiomyoma*, which contains non-striated muscle-fibre. In addition to the muscle-fibre these tumors contain a

often involved,—external, middle, or internal,—and sudden deafness may develop; the *eyes* may be affected in the form of *keratitis*, and the permanent teeth furnish the most important evidence of the disease, —"Hutchinson's teeth." The upper median incisors are stunted, short, "pegged," and often widely separated. The cutting edge is narrow, crescentic (not serrated), and sometimes projects forward rather than downward. There is sometimes a collar-like enlargement at the diaphyso-epiphyseal junction of the long bones.

PROGNOSIS.—The prognosis in hereditary syphilis is much more unfavorable than in the acquired form. About one-fourth die within the first six months. If they survive this period the chances are slightly in their favor. The prognosis is more favorable when the first symptoms of the disease appear after six months.

TREATMENT.—Treatment may be divided into prophylactic and curative. *Prophylactic treatment* relates to the prevention of the hereditary form of the disease by advice as to the proper time for marriage and the prevention of the acquired form by excision of the chancre in cases which seem suitable. The patient should be given to understand that treatment is necessary over a period of from two and a half to three years. Consent to the marriage of a person affected with syphilis should not be given usually until after the lapse of three or four years from the beginning of the symptoms, and under no circumstances until at least six months after the last appearance of any of the phenomena of the disease. *Excision* of the *chancre* as soon as it appears, and in some cases of the *enlarged inguinal glands*, has been practised, on the theory that the virus or microbes were limited to these parts, not yet having entered the general system; but the results have not been encouraging.

Curative Treatment.—The indications are, first, to *destroy* the *virus* or to neutralize its effects on the tissues; second, to *sustain* the *strength* of the patient and treat the anæmia which usually occurs during the prolonged course of the disease. *Mercury* and *iodide of potassium* are considered specifics in the treatment of syphilis. On account of the danger of salivation, the inconvenience of a prolonged course of treatment, and the possibility of retarding the appearance of the secondary symptoms and obscuring the diagnosis, the administration of mercury should not begin until a *positive* diagnosis has been made,—that is, until the appearance of symptoms of the *secondary stage*. Mercury seems to act by causing disintegration of the products of the disease, while iodide of potassium aids its elimination; hence, mercury is given in the early stages and iodide of potassium later. In the later stages some give a mixed treatment of mercury and iodide of potassium. Mercury seems also to act as a tonic, thereby counter-

acting the anæmia which occurs so frequently, and as a *physiological antidote* to the syphilitic poison, possibly as a germicide. It may be given by the *stomach*, by *inunction*, by *fumigation*, by *hypodermatic injection*, and by *intravenous injection*. The preparations of mercury most frequently used are the protiodide, bichloride, calomel, gray powder, blue pill, and the ointment of mercury. The *protiodide* is given in pill form, in doses of $\frac{1}{6}$ to $\frac{1}{3}$ of a grain three or four times daily. For irritation of the stomach or bowels it may be combined with opium, $\frac{1}{20}$ or $\frac{1}{10}$ of a grain to each pill. Corrosive sublimate may be given in doses of $\frac{1}{30}$ to $\frac{1}{15}$ of a grain, in combination with compound tincture of cinchona; and gray powder in $\frac{1}{4}$ to 1 grain doses, three or four times daily, combining it with Dover's powder, if necessary, to prevent diarrhœa. By *inunction*, 1 drachm of the unguentum hydrargyri is rubbed into the skin daily for a month or six weeks. In young children it may be used in the proportion of 1 to 8, applied on a flannel bandage. *Fumigation* is used in the treatment of obstinate eruptions or where a quick result is desired, by vaporizing calomel under the patient seated naked on a chair and covered with a blanket. *Hypodermatic injections* are open to the objection of being very painful and sometimes producing abscesses. A good formula is: Bichloride of mercury, 32 grains; chloride of ammonium, 16 grains; and distilled water, 2 ounces. Ten minims are injected through a platino-iridium needle, in the gluteal region, once a week for six or seven weeks, and then at longer intervals (Cooper). *Intravenous injections* of 20 minims of a 1 per cent. solution of cyanide of mercury every other day, or daily, are recommended by Lane. In using mercury the *dose* for each individual has to be found by trial. A good way is to give the patient a small dose, say one-sixth of a grain of the protiodide three times a day, gradually increasing it until slight soreness of the teeth is felt. Then diminish the dose one-half or one-third, and continue for two years, omitting every third month. Avoid salivation. Iodide of potassium is given in doses of 5 to 20 grains, but in syphilis of the nervous system, with gummata in the brain, large doses gradually increased to as much as an ounce in twenty-four hours have been given with decided benefit. After treatment with the iodide of potassium for six months keep the patient under observation six months longer, when, if no symptoms have appeared, he may be pronounced in all probability cured. Tonic and supportive treatment is often necessary in the form of cod-liver oil or bitter tonics. Hot baths and the drinking of hot water, as practised at certain hot springs, are advantageous in stimulating the emunctory organs, thereby enabling the patient to take larger doses of mercury and iodide of potassium.

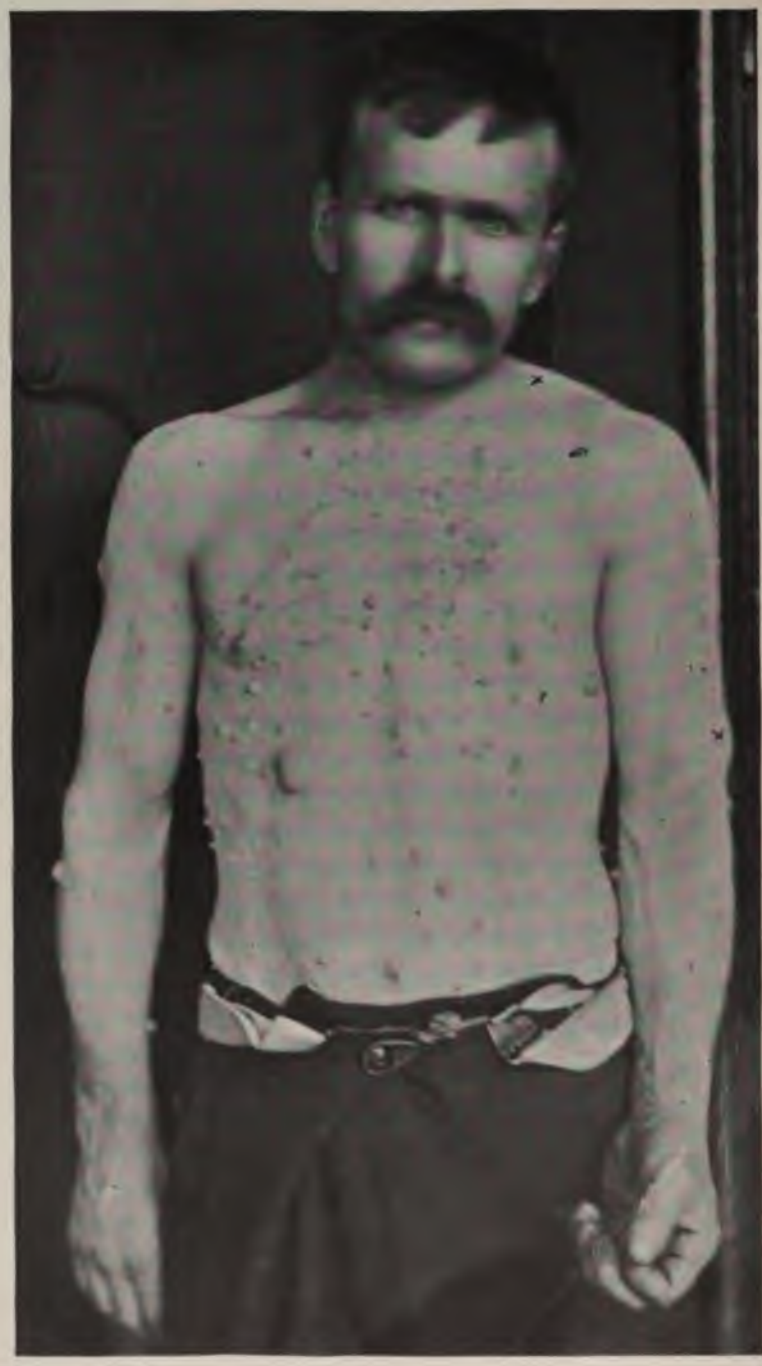


Fig. 85.—Molluscum fibrosum, with sarcomatous degeneration in many of the tumors.

There is an inflammatory, swollen, boggy condition of the parts, gradually merging into the healthy tissues, in contrast with the hard, sharply-limited sensation of a foreign body in the parts, so characteristic of chancre. The microscope shows infiltration with small round cells which destroy or soften the connective-tissue trabeculæ. In number chancroids are usually multiple. They may be multiple from the beginning, or become so by autoinoculation,—inoculation of healthy skin with pus from the first sore,—intentionally or accidentally, producing sores similar to the first.

DURATION.—Ordinary cases recover in five or six weeks; if complicated with buboes or phagedæna the disease or complication may continue six months or longer.

COMPLICATIONS.—These are: Bubo, phagedæna, gangrene, phimósis, and paraphimosis. *Bubo* occurs in from fifty to seventy-five per cent. of all the cases, and usually suppurates. While the bubo is generally unilateral, it is not infrequently bilateral. No micro-organisms have been found in the contents of these buboes, but they are supposed to be due to micro-organisms or to toxins which come from the chancroid. *Phagedæna* may affect the chancroid or an open bubo, and is characterized by a rapid, relentless spread of the ulceration,—the entire penis being sometimes destroyed or the testicles or abdominal muscles laid bare. The *cause* is supposed to be a germ or toxin (unknown) or some dyscrasia.

TREATMENT.—If seen early—before infection of the lymphatics—excision with the knife or scissors and suture of the wound may be tried. Otherwise aim to get cleanliness without irritation,—using bichloride 1–5000, twice daily, followed by the application of iodoform powder or salve, aristol, bismuth subgallate or subnitrate, calomel, or oxide of zinc. Place a thin layer of absorbent cotton between the sore and the prepuce or glans. *Phimosis* or *paraphimosis* requires slitting up of the prepuce. The *bubo* should be excised at its earliest appearance, before suppuration, the wound closed, and the patient kept in bed. If suppuration has occurred, use hot applications till the entire gland is broken down; evacuate the pus through a small incision, wash out the cavity with bichloride 1–3000, and fill with iodoform emulsion, ten per cent. in glycerin or warm vaseline, and apply a compress to prevent its escape. If this fail, open freely, curette, and pack with iodoform gauze. The deep lymphatic glands along the iliac vessels may require removal. This may be done by the incision used for ligating the external iliac extraperitoneally. *Phagedæna* should be treated by thorough excision or cauterization with nitric acid, then simple antiseptic dressings, iodoform, solution of bichloride, tonics, and good hygiene.

Diagnosis.—Fibromata generally appear as hard, ovoid, nodulated tumors, of slow and painless growth, unless involving nerves. The *soft* variety is smooth, round, elastic, soft, often pedunculated, and when occurring in the form of polypi bleeds easily.

The *treatment* is excision.

Keloid is a form of fibroma affecting the skin. It occurs most frequently in the negro race in connection with scars, about the ears, neck, breast, or back. It forms a dense flat tumor in the skin, of a red or pinkish color, with projections reaching into the surrounding skin somewhat like claws,—hence its name. Keloid may be single or multiple, and grows slowly. The *treatment* of keloid is very unsatisfactory. Probably no treatment is best.

FIG. 86.—Keloid.

LIPOMA is a tumor composed of fatty tissue produced from a matrix of lipoblasts (Senn). Lipomata are composed of fat vesicles held together by connective tissue in which the blood-vessels ramify. They are usually encapsulated, grow slowly, are painless, generally single, but may be multiple, or symmetrical, and do not recur when removed.

Sites of Occurrence.—Wherever fatty tissue occurs, and sometimes where it does not occur,—usually beneath the skin, on the shoulders, neck, back, nates, in the breast, in the inguinal and femoral regions; and beneath the periosteum or synovial membrane as lipoma arborescens or racemosum in the knee and shoulder joints.

Diagnosis.—The fatty tumor appears as a rounded or flattened growth, painless, lobulated, soft, with a sensation of semi-fluctuation. If beneath the skin, dimpling is seen on pinching up the skin, due to the presence of fibrous septa which unite the skin to the capsule of the tumor.

The *treatment* consists in excising the tumor with its capsule.

A CHONDROMA is a tumor composed of cartilage which is the

product of tissue-proliferation from a matrix of chondroblasts (Senn). It is composed of hyaline fibrocartilage, or reticular cartilage, which occurs in one or more masses enclosed in a capsule of fibrous tissue. On section the cut surface appears of a bluish-gray or pinkish-white color, and is homogeneous or closely granular. A thin section is translucent. The cartilage-cells are seen scattered or in groups, embedded in the fibrous or hyaline tissue. Chondromata may be single or multiple; are usually small, but may attain a very large size; and are of slow growth. They form hard, rounded, sometimes elastic or lobulated growths, usually in connection with bones, but occasionally in soft tissues. They frequently occur in the young. Degenerative changes are fatty or mucoid, with cysts. Ossification, or excessive development of fibrous tissue, may occur and produce an osteochondroma or a fibrochondroma. Arrest of the development of the tissue-cells in their embryonic condition produces sarcomatous tissue.

Sites of occurrence are the phalanges of the fingers and toes, where they are often multiple; the lower epiphyseal region of the femur, the upper ends of the tibia, fibula, and humerus; the scapula and ilium; the periosteum of the jaws (epulis); in connection with joints; in the parotid gland, breast, testis, ischiorectal space, and subcutaneous tissue.

Treatment.—Early and complete removal.

An OSTEOMA is a tumor composed of compact or cancellous bone produced from a matrix of osteoblasts (Senn).

Histology and General Character.—Compact osteomata contain no Haversian canals and are so hard that they can scarcely be cut. The *cancellous osteomata* may come from ossification of chondromata in the long bones. Occasionally they occur in the interior of bones, when they are called *enostoses.* Osteomata appear as hard rounded tumors, often with a pedicle and sometimes lobulated. They are painless and usually small in size, especially the compact variety, but the cancellous variety sometimes grows to quite a large size. They grow slowly and may remain stationary, and seldom degenerate.

Sites of Occurrence.—Compact osteomata occur on the frontal, sphenoid, and superior maxillary bones, in the nasal sinuses, and on the phalanges,—especially the ungual phalanx of the great toe; the *cancellous* variety, near the epiphyses of the long bones. They sometimes develop in the deltoid and adductor magnus muscles in soldiers and riders and in the affection known as *myositis ossificans.*

Treatment.—Removal, except when on the sphenoid or ethmoid and giving no trouble.

A LYMPHOMA is a tumor composed of lymphoid or adenoid tissue.

Its general structure is that of the lymphatic glands, consisting of a delicate reticulum of fibrous tissue within the meshes of which are contained lymph-corpuscles. The size and rapidity of growth depend on the relative proportion of the stroma and cells, those containing a large proportion of stroma being small and growing slowly while those containing more cells than stroma are soft in consistence and rapid in growth, sometimes reaching a large size. As a rule, lymphomata are innocent tumors; sometimes, however, the stroma of lymphoma undergoes changes into embryonic connective tissue and gives rise to lymphosarcoma, as in Hodgkin's disease.

Sites of Occurrence.—The lymphatic glands, either singly or in groups, occasionally as a result of injury. In Hodgkin's disease lymphomata develop not only in the lymphatic glands but also in the internal organs, such as the spleen, liver, kidneys, lungs, and medulla of bones.

An ODONTOMA is a tumor composed of dental tissue arising from teeth germs or from growing teeth. They may develop from the enamel-organ, the tooth-follicle, the papilla, or from the whole germ.

FIG. 87.—Follicular odontome

The diagnosis must be made from *epulis*, especially the sarcomatous variety, as the operation for sarcoma might require a mutilating operation unnecessary in odontoma. Sarcoma may be recognized by the rapid growth, enlarged blood-vessels, or, finally, by microscopic examination of a section of the tumor before completing the operation of removal.

A MYXOMA, or mucous tumor, is composed of tissue resembling the vitreous humor of the eye or the Whartonian jelly of the umbilical cord. A section under the microscope shows stellate cells with branching processes that anastomose with one another and form an irregular network of stroma containing a gelatinous substance. A few blood-vessels are found in the stroma. In appearance myxomata are soft, gelatinous, semitranslucent, and encapsulated, with fibrous septa running through them. They grow slowly. Myxomata are

also produced by degeneration in other tumors, as sarcoma, chondroma, and fibroma.

Sites of Occurrence.—The nasal cavities as gelatinous polypi; the breast; the brain; near the umbilicus; in the submucous and subserous tissues and intermuscular spaces; in connection with the periosteum, the medulla of bones, and the sheaths of nerves.

The treatment is removal.

III. Type of Embryonic Connective Tissue.—This consists of one class only,—namely, sarcoma.

SARCOMA is a malignant tumor composed of embryonic connective tissue.

Structure.—Sarcomata are composed of cells and intercellular substance. The cells are without a limiting membrane, contain from one to thirty nuclei with nucleoli, and constitute the greater part of the growth. There are three principal varieties of cells—round, spindle, and myeloid—and all may be found in a single tumor, but usually one variety predominates. The *intercellular substance* is scant, but exists between all the cells: "the cells are in constant relation with the stroma." The consistency of the growth depends on the proportion between the cells and stroma. True alveoli do not exist, as in cancer. Blood-vessels are numerous and in direct contact with the cells or separated from them by a small amount of fibrillated tissue. The walls of the blood-vessels are sometimes formed by the cells—hence the ease with which generalization or hemorrhage takes place. Lymphatics are not usually found in the tumor, though involvement of the lymphatics may be expected if the tonsil or testis is affected. The edges of the tumor always represent the newest and least mature part, and consist of an excess of small round cells. Sarcomata exhibit nearly every stage in the development of connective tissue: (1) Round cells which cannot be distinguished from granulation tissue. (2) Cells of elongated spindle shape, the intercellular substance showing an attempt at fibrillation and the formation of fibrous tissue. (3) Further development may take place into cartilage or bone, but sarcomatous elements always exist at the growing margins.

Origin.—Sarcomata always originate from connective tissue, whether from the adult tissue as skin, etc., or from embryonic remains, as warts and pigment spots.

Varieties.—The varieties, according to the predominant cell, are round-, spindle-, mixed-, and myeloid- or giant-celled sarcoma.

1. **Round-celled sarcomata** are composed of round cells of varying size, resembling leucocytes, embedded in a small amount of granular or homogeneous basic substance. On section they resemble brain tissue; they are soft, vascular, grow rapidly, often attain a large

size, and early give rise to metastatic deposits in internal organs. Degenerative changes are common, with hemorrhage, the formation of blood cysts, and mucoid softening.

Sites of Occurrence.—Periosteum, bone, lymphatic glands, subcutaneous tissue, testicle, eye, ovary, uterus, lungs, and kidneys—in fact, any connective tissue.

Subvarieties.—(*a*) *Glioma* consists of small round cells and grows from the connective tissue of nerves, in the retina and brain. It is often an innocent tumor, resembling fibromyoma. Strictly speaking, the glioma does not belong to the sarcomata, as it develops from the epiblast. (*b*) *Lymphosarcoma* is a variety of round-celled sarcoma composed of cells lying in a delicate reticulum resembling lymphoid tissue. (*c*) *Psammoma* is a nest-celled sarcoma (or fibroma—

FIG. 90.—Sarcoma of the lower end of the radius: *a*, normal wrist; *b*, sarcomatous tumor.

Green), found in the pineal gland, the membranes of the brain, and the choroid plexus. It usually contains calcareous particles—brain sand. (*d*) *Alveolar sarcoma* may be round or spindle celled. The stroma encloses groups of cells in spaces resembling alveoli, but on close examination stroma is found separating the individual cells. It occurs in the skin, bones, and muscles. (*e*) *Melanotic sarcoma* belongs to either the round- or spindle-celled variety. Both cells and intercellular substance are infiltrated with dark-colored pigment. It

FIG. 88.—Round-celled sarcoma of the face.

FIG. 89.—Further growth of sarcoma of the face, showing marked degenerative changes. (International Clinics.)

FIG. 91.—Sarcoma of the knee, sawed in two.

occurs in the skin and choroid of the eye; the metastatic growths are also pigmented.

2. **Spindle-celled Sarcoma.**—This represents a step higher in the scale of development, and is composed of oat-shaped or spindle-shaped cells, sometimes with long tapering extremities, separated by a little homogeneous or slightly fibrillated intercellular substance. It is liable to the usual degenerative changes, or it may develop into cartilage or bone, forming chondrosarcoma and osteosarcoma. The *subvarieties* are (*a*) large-celled, (*b*) small-celled, and (*c*) melanotic sarcoma.

Sites of Occurrence.—Skin, subcutaneous tissue, fasciæ, intercellular septa, periosteum, interior of bone, eye, antrum, breast, and testis.

3. **Mixed-celled sarcoma** is composed of a mixture of round and spindle cells, or cells of many different forms and sizes, no one type prevailing; found chiefly in connection with the bones.

4. **Myeloid or Giant-celled Sarcoma.**—This tumor contains many giant cells and a varying number of round, spindle, or mixed cells. The tumor is soft or firm like muscle. On section it shows a shining translucent surface of a dark-red color, without fibrillation. It is often encapsulated and sometimes so vascular as to give rise to pulsation.

Sites of Occurrence.—The lower jaw, as one form of epulis; the lower end of the femur and upper end of the tibia, and the interior of bones.

FIG. 92.—Osteosarcoma of the femur.

Clinical Course of Sarcomata.—This depends on the *variety* of the sarcoma and on the organ attacked. The round-celled are the most malignant and the myeloid-celled the least so. The myeloid sarcoma of the lower jaw may grow for years, while a melanotic round-celled sarcoma causes rapid dissemination, often involving the lymphatics, and early death. Sarcomata originating in the eye or brain are seldom larger than a walnut, while those springing from bone are sometimes as large as an adult head. A *capsule*

may form on those which develop in the subcutaneous tissues, but this does not occur with the tumors connected with the bones, tonsil, or lymphatic glands. Death usually results from metastasis producing secondary growths in the lungs, kidneys, brain, or other organs.

Diagnosis. — The diagnosis must be made from inflammatory troubles and from other tumors, especially carcinoma. In *sarcoma* the skin is not so apt to be involved as in carcinoma. The lymphatics are seldom affected, except in sarcoma of the tonsil, testis, or lymphatic glands. In sarcoma there is greater rapidity of growth, enlargement of the veins over the tumor, the formation of cysts, and the occurrence of metastases at an earlier period. Sarcoma of the jaw should be distinguished from *odontoma* and from *fibrous epulis.*

Prognosis.—The prognosis depends on the structure of the tumor, its location, and the treatment available. Without treatment the most malignant forms, as melanotic sarcoma and sarcoma of the tonsil or lymphatics, destroy life as rapidly as carcinoma.

Treatment. — The tumor and the nearest group of lymphatic glands, whether infected or not, should be removed as early as possible. In case of the limbs, amputation should be done through the joint above, in order to remove the entire bone affected. If the tumor originate in the *tonsil* or *lymphatics*, there is little hope unless removed in the earliest stage of the disease. A few cases of sarcoma have been cured by an attack of erysipelas. On this principle, the mixed toxins of the streptococcus erysipelatis and bacillus prodigiosus have been used by hypodermatic injection into the tumor.

IV. ENDOTHELIOMA.—This tumor is supposed to represent the transition between the connective-tissue and the epithelial tumors,—between sarcoma and carcinoma. An *endothelioma* is composed of large irregular, flattened, or rounded cells contained in a stroma of connective tissue. The spaces in this tissue often form convoluted tubes, which are filled with cells forming strings or cell masses. These tumors spring from the endothelium which lines the lymphatic vessels, blood-vessels, and lymphatic spaces. From this origin they should belong to the connective-tissue tumors, but the great proliferation of cells gives them a close resemblance to epithelial tumors. Ziegler calls them *organoid sarcomata*,—that is, sarcomata with the elements of organoid tumors—epithelium—as a part of their structure.

Sites of Occurrence.—The lymphatics of the skin, the pleura, pericardium, and peritoneum; the endothelium of the arachnoid and the lymphatics of the dura mater; also the breast and ovary. They appear as small, flat nodules in the skin or membrane in which they

originate, and may be single or multiple. They grow slowly, with little tendency to infiltration of the surrounding tissues.

Treatment.—The same as that for the other malignant tumors.

B. EPIBLASTIC AND HYPOBLASTIC TUMORS.

V. Type of Epithelial Tissues.—These comprise tumors which originate from the epiblast and hypoblast, and may be subdivided into (1) those of *high* development and (2) those of *low* development.

1. Under those of HIGH DEVELOPMENT are: (*a*) Papilloma, (*b*) adenoma, and (*c*) cystoma. These are benign tumors.

(*a*) PAPILLOMA.—A papilloma is a tumor composed of connective tissue surrounding capillary loops or networks of blood-vessels and

FIG. 93.—Papilloma (wart) of the skin.

covered by one or several layers of epithelial cells. It may occur singly as small growths, or where several are combined as cauliflower masses.

Varieties.—*Warts*, which appear as small circumscribed growths or as larger masses on the skin or mucous membranes. On the skin they are covered with a layer of horny epidermis and have a small blood supply. *Villous tumors,—warts of mucous membranes*, or *soft warts.* These are long, delicate papillæ, single or combined (dendritic), very vascular, bleed readily, and are found in the bladder, larynx, cheek, and on the tongue. *Mucous tubercles*, or *condylomata.* In these the papillæ are enlarged and flattened, the connective tissue

is infiltrated with round cells, and the epithelial covering is moist and sodden. They commonly result from syphilis, and are found in the mouth, throat, and about the genital organs. *Corns.* Corns commence as papillomata, but the papillæ ultimately atrophy from the pressure of the hard, thickened layers of epidermis. *Horns.* Horns are a modified form of epithelium and sebaceous secretion, originating from sebaceous follicles or cysts, and it is said that long papillæ project into their bases. They are seen on the head and face.

(*b*) ADENOMA.—An adenoma is a tumor composed of gland tissue similar in character to that in which it originates, but having no communication with it. It is usually encapsulated and innocent, but

FIG. 94.—Adenoma of the breast. The section reveals a great overgrowth of connective tissue and a marked proliferation of the acini and ducts. Histologically the latter are typical, but in some sections they were much compressed, whereas in others they were the seat of slight cystic dilatation. Oc. 3, Ob. AA.

may undergo malignant changes into sarcoma or carcinoma. There are two kinds: 1. *Acinous* or *racemose*, which consist of lobules united by means of connective tissue. According to the amount and kind of tissue there may be adenofibroma, adenomyxoma, adenocystoma. The acinous adenoma is found in the breast, lip, ovary, prostate, testis, thyroid, parotid, lachrymal, and cutaneous glands. 2. *Tubular adenomata*, which consist of simple tubules lined with cylindrical epithelium, and are found in connection with the mucous membranes that contain such glandular tubules, as the intestines.

(*c*) CYSTOMA.—(See TERATOMATA and CYSTS.)

2. TUMORS OF EPITHELIAL TISSUES OF LOW DEVELOPMENT.—These are malignant tumors or cancers.

CARCINOMA.—A carcinoma is an atypical formation composed of cells of the epithelial type "in constant relation with one another," and forming nests surrounded by stroma. The cells are characterized by their large size, diversity of shape, and the permanence of their nuclei and nucleoli. They are round, oval, fusiform, caudate, or polygonal from mutual compression. There is no specific cancer cell. The *stroma* varies in amount, and consists of fibrillated tissue arranged so as to form alveoli of various shapes and sizes, within which the cells are grouped. It does not penetrate between the cells as in sarcoma. *Blood-vessels* are often numerous, and form a close network around the alveoli, but are limited to the stroma and never pass into the cell masses. *Lymphatics* communicate freely with the alveoli; in fact, the alveoli may be considered dilated lymphatics, for the epithelial columns grow along the lymphatic spaces; hence the great tendency to infection of the lymphatic glands.

Origin.—Carcinoma always originates from epithelium—surface or glandular—the epithelium growing and overcoming the physiological resistance of surrounding tissues, penetrating the basement membrane and spreading in the lymph spaces. Cohnheim's theory of a "resting spore" would explain its origin in connective tissues as nævi.

Clinical Character.—Cancers are rare before the age of thirty-five and steadily increase in frequency after this age. The primary growth is nearly always single. *Encephaloid* is the most malignant variety; *epithelioma* and *atrophic scirrhus* the least. They grow rapidly, widely infiltrating the surrounding part, soon infect the lymphatic glands, and become generally disseminated. When removed, unless excised early and freely, they recur in the same locality. They break down frequently from fatty degeneration, bleed, and form offensive sores.

Varieties.—There are two varieties of cancer, each of which has subdivisions: (*a*) the glandular, round-celled carcinoma, and (*b*) epithelial, flat or cylindrical-celled carcinoma, or *epithelioma*.

(*a*) **The glandular, round-celled carcinoma** originates from the epithelium of acinous or tubular glands. There are three subdivisions.

1. **Hard, Round-celled Carcinoma, Scirrhus, Chronic Cancer.**—*Histology and General Character.*—*Scirrhus* contains a good deal of fibrous tissue, arranged so as to form nests or alveoli which contain groups of round cells and cells of various forms. On section it is firm and the surface appears white, cupped, and yields on pressure or when scraped a milky fluid called "cancer-juice." Fibrous septa may be seen traversing the structure. Rarely, if ever, encapsulated, it infiltrates the tissues to a great degree, in some cases no definite

tumor being present, only nodules and cord-like bands throughout the affected organ.

Symptoms.—Scirrhus appears as a hard, irregular, tuberous growth of moderate size, depressed in the centre, and at first freely movable with the gland, but later by infiltration it becomes fixed by adhesion to the skin, fascia, muscles, or bone. The nearest lymphatic glands are enlarged, metastases take place in the viscera, and, finally, ulceration of the superjacent tissues. The ulcer is irregular in appearance and depth, with hard, nodular, everted margins, sometimes covered with offensive sloughs. There are generally no granulations, and the base of the ulcer is hard and irregular. The organs most frequently affected are the female breast, stomach, liver, pancreas, prostate, and mucous and cutaneous glands.

Duration of Life.—The duration of life is about two years; occasionally, with external tumors, twenty years.

Withering or *atrophic scirrhus* is a form of scirrhus of the breast containing an excessive amount of connective tissue, the contraction of which causes the tumor to shrivel up into a nodule.

2. **Soft, Round-celled, Medullary, or Encephaloid Cancer.**—This variety differs from scirrhus in containing more cells and less fibrous tissue. On section it resembles brain substance in appearance and consistence, especially about the periphery, while the central parts may be soft and diffluent. Cyst-like cavities and in some organs, as the breast and testis, true cysts may be formed. Blood-vessels are often abundant.

Symptoms.—It forms large soft masses, grows rapidly, and finally ulcerates, forming a bleeding mass, or *fungus hæmatodes* of the older writers. As *primary* growths it occurs in the testis, liver, bladder, kidney, breast, ovary, and fundus oculi; as *secondary* growths or metastases, in the skin, bones,—especially the vertebræ,—liver, lungs, kidneys, and brain.

Duration.—The average duration of encephaloid cancer is from one year to eighteen months.

3. **Colloid cancer** is simply scirrhus or encephaloid in which colloid degeneration has taken place. The alveolar structure is marked, large, and round, and contains colloid material,—a gelatinous, colorless, or yellowish substance in which epithelial cells containing the same material are embedded. It is found most frequently in the stomach, intestine, omentum, ovary, and, occasionally, the mammary gland.

Diagnosis of Cancer.—The diagnosis must be made by considering the age—forty or more; its origin, in the epithelium lining glands, and therefore *beneath* the surface of the skin or mucous membrane,

except in epithelioma; the early lymphatic infection; the rapid growth and the infiltration of surrounding tissues, becoming fixed to the deeper structures as well as to the skin; ulceration of the skin, forming an offensive bleeding sore with irregular edges; and, later, the development of cachexia.

(*b*) EPITHELIOMA.—Epitheliomata are subdivided into *squamous* and *cylindrical*. *Epitheliomata* originate in surface epithelium either of the skin or of the mucous membrane, occasionally from gland epithelium, so that the line between glandular and surface cancers cannot always be sharply drawn. *Squamous epithelioma* arises from surface epithelium of the *flat*, *pavement*, or tessellated variety.

Histology and General Character.—On section a *squamous epithelioma* presents a smooth grayish surface. On squeezing it, cancer-cells are forced from the lymph spaces on the cut surface as small, white, twisted, thread-like bodies similiar to comedones. Microscopic examination of a section shows the *cells* flattened and distorted in shape, growing down from the surface epithelium into the lymphatics of the connective tissue, forming solid cylinders, which twist about, branch, and swell at points. On cross section these cylinders appear as round or oval masses of cells arranged in concentric layers—onion-like—forming *epithelial nests*, or *epidermic pearls*, the centre of which has usually degenerated from compression into a fatty or caseous material. The stroma varies in appearance between embryonic and fibrillated tissue, and may be abundant or almost wanting. It rarely forms a marked alveolar structure as in carcinoma, but consists simply of the fibrous tissue of the part, more or less infiltrated with small round cells.

Etiology.—Prolonged irritation often seems to be the cause, as epithelioma of the lip and tongue of smokers and of the scrotum in chimney-sweeps.

Symptoms.—*Squamous epithelioma* begins as a small hard ulcer, an indurated fissure, a nodule, or a wart-like growth, in or on the skin or mucous membrane. It may start in a chronic ulcer or in a wart or congenital mole. As an ulcer it appears irregular in shape, with everted ragged edges, perhaps a sloughing surface, but often clean and covered with large, firm, bluish-red granulations, sometimes warty. Its rapidity of growth depends on its location. On the lip or skin of the face it grows slowly, possibly for twenty years, but irresistibly, gradually destroying everything in its pathway, including soft tissues and bone alike. When it occurs on the tongue or originates in congenital moles or nævi, epithelioma is more malignant and rapid in its course. Lymphatic involvement occurs early when the tongue is the seat of the disease, but late when other parts are involved.

Visceral infection seldom takes place. Recurrence after removal is common, unless the operation has been done early and completely, and death is due to exhaustion from ulceration and hemorrhage.

Sites of Occurrence.—The skin of the nose, cheeks, penis, scrotum, and, rarely, of the hand and foot; at the mucocutaneous junctions, on the lower lip, eyelids; on the mucous membranes of the tongue, palate, gums, tonsils, larynx, pharynx, œsophagus, bladder, and *os uteri*.

Diagnosis.—The patient is usually a male over forty years of age. The chronic character of the growth, with the induration and resistance to treatment, should excite suspicion, and a piece can be removed for microscopic examination. On the tongue it must be distinguished from *gumma*. Cancer is characterized by first appearing *in* rather than beneath the surface, by its ragged, everted edges and tendency to bleed, by the involvement of the submaxillary glands, and the pain, stiffness, and loss of function of the tongue, in all of which points it differs from gumma. *Rodent ulcer*, or *Jacob's ulcer*, is a form of skin epithelioma of slow growth, sometimes fifteen to twenty years. It may be distinguished from ordinary epithelioma by the small size of its cells, by the absence of prickle-cells, by the slight tendency to become scaly and form nests, and by the ease with which the epithelium columns can be traced (Green). *Cylindrical* or *columnar epithelioma* is less common than the other forms of cancer, and arises from mucous membrane, sometimes glands, provided with cylindrical epithelium. The cells are similar to those of the mucous membrane from which they spring and are arranged perpendicularly to the walls of the alveoli formed by the stroma. Cell nests are not found. When they originate from gland cells they often form gelatinous growths on account of colloid degeneration. They form indurated masses in the walls of hollow viscera—intestines, stomach, and uterus—and the first symptoms may be caused by stenosis. Ulceration occurs, followed by hemorrhage. Lymphatic involvement is usual, and then infection of the lungs, liver, and other viscera.

Treatment of Cancer.—Drugs may be said to have little or no effect, although a few cures of lymphosarcoma from the use of arsenite of sodium have been reported. Some cases of superficial epithelioma have been reported cured by the Roentgen ray. The whole organ affected, including the skin attached, should be removed when practicable, cutting through sound tissues at least one inch beyond the margin of the disease and removing the nearest lymphatic glands. When a limb is affected, amputation well above the cancer should be done, and in most cases the inguinal or axillary glands nearest should be removed. Some plastic operation may be required to cover with

FIG. 95.—Epithelioma of the eyelids.

FIG. 96.—Recovery from epithelioma of the eyelids after treatment with the Röntgen ray. (Merrill.)

skin the surface exposed after excision of cancer of the face or trunk. Operation is sometimes justifiable when cure is impossible, in order to relieve pain, hemorrhage, or obstruction to the lumen of an organ. The prospect of cure is good if done early enough, except in cancer of the œsophagus, tonsil, or testis. When general infection has taken place cure is impossible, and palliation is all that can be done. This consists in keeping the ulcerated surface clean by the use of antiseptics, as carbolic acid, iodoform, aristol, bichloride, or permanganate of potassium. Pain may require the use of morphine, local or internal, or of cocaine dusted over the ulcer or used in solution.

C. TUMORS COMPOSED OF TISSUES DERIVED FROM MESOBLAST, EPIBLAST, AND HYPOBLAST.

VI. Teratomata.—*Teratomata* are congenital tumors, or monsters. They include *dermoid cystomata*, and are found in the ovary, testis, head, neck, and sacral region. Some of the theories of their origin are as follows:

1. Cohnheim's theory of "embryonic remains," according to which a portion of embryonic tissue becomes displaced in fetal life and may be enveloped in the ovary, or any other organ, where it lies dormant until from some stimulus in later life it develops into a dermoid cystoma. 2. Wilms's theory, that dermoids are rudimentary embryos or parasites which develop from a single ovum. 3. The theory of *fetal inclusion*. According to this theory two ova are impregnated at the same time; one develops normally while the other develops imperfectly and is included in the tissues of the former. They are called *bigerminal teratomata*. The host is called the *autosite* and the contained fœtus or portion of a fœtus the *parasite*. If partial fetal inclusion takes place, the acardiac parasite may be partially destroyed, leaving the four extremities, two extremities, or one extremity, as the case may be, engrafted on the autosite, giving him sometimes four arms and four legs, or three arms or three legs, according to the number of limbs belonging to the parasite. The most complete form of fetal inclusion is that of *fœtus in fœtu*. In the museum of the College of Physicians and Surgeons in London is a specimen of a boy, well developed, who died at the age of fourteen years, and at the post-mortem there was found in his abdominal cavity a full-grown fœtus, surrounded by a sac or membrane (Senn). Dermoid cystomata, which are so frequent in ovarian tumors, usually contain bones, teeth, hair, and pultaceous (sebaceous) material.

Cysts and Cystic Tumors.

A cyst is a cavity containing a fluid or semi-solid substance, which is separated from the surrounding tissues by a capsule of fibrous tissue lined with epithelium or endothelium. It may originate in a pre-existing structure which has become distended by its own secretion or by the extravasation of fluid into it, or it may be a new formation, a cystoma,—a true tumor. Cysts may be classified as follows:

I. Cysts formed by the accumulation of substances in pre-formed spaces, including: (*a*) Exudation cysts, (*b*) retention cysts, (*c*) extravasation cysts.

II. Cysts due to parasites or foreign bodies.

III. Cysts of new formation, including congenital cysts.

I. Cysts formed by the Accumulation of Substances in Pre-formed Spaces.—(*a*) EXUDATION CYSTS are formed by excessive secretion in closed cavities, or cavities not provided with an excretory duct, as *bursæ*, *ganglia* in connection with the sheaths of tendons, and *hydrocele*.

(*b*) RETENTION CYSTS are caused by the retention of normal secretion in a gland or duct owing to obstruction to its outlet, as sebaceous, mucous, salivary, etc.

Sebaceous cysts are seen most frequently on the scalp and face, but may occur anywhere that sebaceous glands exist. They appear as smooth, flat, firm, or semi-fluctuant tumors. The orifice of the obstructed duct may be indicated by a small black spot or plug resembling a comedone. The contents are pultaceous, cheesy, white or yellowish in color, and often offensive in odor.

The *diagnosis* may be made from fatty tumors and abscesses by the absence of dimpling and the presence of a small dark spot somewhere on its surface, indicating the mouth of the occluded duct.

Treatment.—The duct may be dilated and the contents squeezed out, but the cyst is apt to fill again. In order to effect a radical cure the cyst, with its wall or capsule, must be removed.

(*c*) EXTRAVASATION CYSTS result from hemorrhage into closed cavities, as hæmatocele, often seen in the sac of the tunica vaginalis.

II. Cysts due to parasites or foreign bodies lodged in the tissues, as bullets, needles, pins, splinters, etc. The most important parasitic cyst is the *hydatid*, due to *tænia echinococcus* (dog tapeworm).

III. Cysts of New Formation, or Cystomata.—A CYSTOMA is a tumor in which the cyst wall is produced from a matrix of embryonic cells and the contents are the products of tissue proliferation of the cells lining the cyst wall (Senn).

Histology and General Character.—The framework of the tumor is composed of connective tissue, while the cells lining its cavity are derived from the epiblast, hypoblast, or mesoblast, and correspond in shape and structure to that of the part of these structures from which the matrix is derived. In cysts from the epiblast the cells are flat; in those from the hypoblast, columnar; and in those from the mesoblast, of the endothelial type.

The *contents* of a cystoma depend on the type of cells lining the cavity: epithelial furnish fatty, columnar cells mucous, and endothelial cells serous contents.

Cystomata may be unilocular or multilocular; they are benign tumors, are usually of slow growth, and are dangerous chiefly from mechanical action, sometimes from infection, occasionally gangrene as from a twisted pedicle, or because of transformation into sarcoma or carcinoma.

Etiology.—They are often congenital; but trauma, prolonged irritation, or physiological activity, as at puberty, may produce the matrix or stimulate into activity a latent one.

Sites of Occurrence.—The ovaries, base of the tongue, neck, orbit, sacral region, testis, bone, and urachus. Cysts of mesoblastic origin are seen most frequently in the neck in connection with the branchial clefts, where they are known as hygromata, hydroceles, or branchial cysts.

The *diagnosis* must be made from papilloma and adenoma. This can usually be done by the more rapid growth and fluctuation of cystoma.

Treatment.—Removal when possible. Branchial cysts of the neck are often connected with the large blood-vessels of that region, and the operation of removal may be very difficult and dangerous. Such cases may be treated by tapping and the injection of five per cent. carbolic solution.

SECTION II.—SURGERY OF SYSTEMS AND REGIONS.

CHAPTER I.

THE VASCULAR SYSTEM.

The Heart and Pericardium.

OPERATIONS on the heart and pericardium may be rendered necessary by reason of disease or injury, as in the over-distention of the heart in acute congestion, as shown by a rapid weak pulse and cyanosis threatening the life of the patient; or effusion into the pericardium of serous or purulent character, coincident with general dropsy, or the result of traumatism or infection with one of the pyogenic organisms, producing acute or chronic pericarditis.

INJURIES OF THE HEART AND PERICARDIUM.—Rupture of the heart occasionally takes place from a blow on the chest, or as a result of exertion or over-distention of the chambers, as from the bursting of an abscess or aneurism, especially if the walls have been weakened by fatty degeneration, suppurative myocarditis, embolism of a coronary artery, or gummatous growths. The spasm of tetanus may cause rupture of the heart. Rupture occurs most frequently in persons over sixty years of age, and, while any chamber may be involved, the lesion is most apt to be in the anterior wall of the *left ventricle* near the septum. The symptoms are a feeling of anguish, oppression, rapid, feeble pulse, syncope, and the patient may die at once or may live for from a few hours to ten days.

Wounds of the heart are not necessarily fatal, as cases have been reported in which foreign bodies, such as needles and bullets, have been carried embedded in its walls for years. Wounds may be caused by needles, knives, daggers, other pointed instruments, gunshot projectiles, or a fragment of fractured rib.

The *symptoms* are variable. Pain is always present, with recurring attacks of syncope, the area of dulness is increased, and the heart-sounds are more or less muffled according to the amount of hemorrhage in the pericardium.

Operations.—Tapping the *cavity* of the *heart* must be performed under the strictest aseptic precautions. Insert a long aspirating needle in the third right intercostal space, close to the edge of the sternum, and thrust it directly backward through the edge of the right lung, the pleura, and pericardium, into the right auricle, removing the blood by means of suction with an aspirator or syringe. This is a dangerous operation and should not be lightly undertaken.

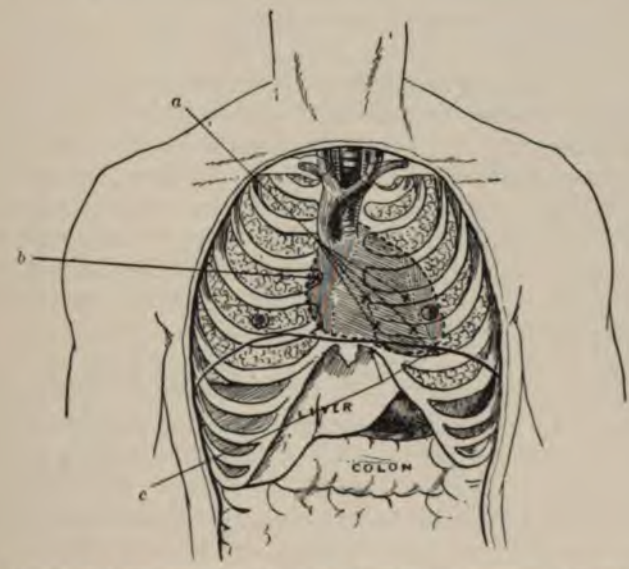


FIG. 97.—Thorax, heart, lungs, etc.: *a*, points where costal cartilages are divided in Roberts's method of exposing the heart; *b*, place to insert needle in paracentesis cordis; *c*, place to insert trocar and cannula in tapping the pericardium.

Tapping the pericardium—paracentesis pericardii—may be done when the accumulation of fluid in the pericardium causes alarming symptoms. Insert the needle into the fifth intercostal space, two inches to the left of the left border of the sternum, and pass it directly backward. The needle may be inserted at another point, and here it is less likely to wound the lung,—namely, in the left triangle between the ensiform and costal cartilages as high up as possible.

In *empyema* of the pericardium, make an incision, resect a portion of a rib or two if necessary, and establish drainage.

Roberts's method of exposing the heart for operation is as follows: Make a chondroplastic, horseshoe-shaped flap by an incision dividing the fourth and fifth costal cartilages close to the sternum on the left side and again near their junction with the ribs. This open-

ing can be made larger by cutting through the ribs. The flap of skin, cartilage, and muscle is turned up, exposing the edge of the left pleura and the pericardium, with the internal mammary vessels in front of the latter. The pleura should be displaced if necessary to the left, the vessels in either direction as may be most convenient, the pericardium incised, the sac washed out with an antiseptic solution, a drainage tube of rubber or of glass introduced, and the wound partially closed. Porter, in 1900, reported fifty-one cases of purulent pericarditis treated by incision and drainage, with twenty recoveries and thirty-one deaths.

Wounds of the heart and pericardium, if they do not cause immediate death, should be treated by putting the patient to bed and keeping him absolutely quiet, with the head low to prevent syncope. If the symptoms do not improve, operation should be done. Several cases have been reported in which wounds of the heart have been successfully sutured. Of thirty-nine cases of suture for wounds of the heart, fourteen recovered. Fine silk continuous or interrupted sutures are used, and the pericardium is usually drained.

FIG. 98.—Varicose veins of the leg.

Varicose Veins, Varices.

Varix is a dilated, elongated, tortuous, knotty condition of a vessel. The veins most frequently affected are the superficial veins of the extremities, the veins of the spermatic cord (varicocele), and the hemorrhoidal veins.

CAUSES.—It is more common in elderly persons, in females, and in those who stand a great deal, as soldiers, sailors, clerks, and floor-walkers. Obstruction to the venous flow from any cause, as garters, tumors in the abdomen or pelvis, pregnancy, fecal accumulation in the colon, or diseases of the heart and lungs, may produce it.

PATHOLOGY.—The venous coats are gradually distended until the valves are no longer competent, and the weight of the column of blood supported by the vein below is increased whenever the valves give way, so that the vein is elongated as well as widened, and assumes an irregular, curved, or tortuous shape, with knots here and there, corresponding to the points of greatest dilatation, just opposite the valves. The coats are thickened by the formation of new tissue, especially in the intima, which may protrude through the other coats

and form a hernia. In old cases all the coats may yield and severe or even fatal hemorrhage occur. Infection frequently takes place, with thrombi or infiltration of the connective tissue with new cells, causing "wooden œdema." "Wooden œdema," according to Reclus and others, is caused by infection with a streptococcus. Eczema is apt to develop on account of the sluggish circulation, and any slight injury may result in the obstinate chronic ulcers, known as *varicose ulcers*, so often seen on the legs of those afflicted with varix of the saphenous vein. The infected thrombi may form abscesses, or they may organize or form phleboliths (vein-stones),—concretions composed of fibrin and the salts of calcium and potassium.

SYMPTOMS.—Of the veins of the extremities the *internal saphenous* and its branches are most frequently affected. The deep veins of the extremities are seldom involved. The appearance is characteristic, the tortuous knotty elongated swelling showing blue through the skin and corresponding with the known location of the veins. Elevation of the part causes the swelling to disappear while standing, if the varix be in the lower extremity, or pressure on the vein above causes increased swelling in the peripheral part. In some cases in which the trunk of the saphenous is principally involved, the vein may be distended by a backward flow from the femoral vein, so that, in spite of pressure applied below the saphenous opening, the cardiac end of the vein will become distended perhaps even more then the peripheral end.

DIAGNOSIS.—Femoral hernia can be distinguished from varix of the saphenous vein by noticing that both swellings disappear in the recumbent position, if the hernia is easily reducible, but if pressure be continued at the saphenous opening and the erect position again assumed, *in varix* the swelling will reappear, provided the vein fills normally from below, while in *hernia* the swelling will not recur. If the vein fill from above from the femoral vein, it may cause some confusion, but can easily be recognized by its elongated shape extending down the thigh and lack of impulse on coughing.

The TREATMENT is palliative and radical.

Palliative.—Avoid all constriction about the limbs which may interfere with the circulation; keep the bowels open, to avoid interfering with the circulation in the iliac veins; treat the heart, liver, and lungs, if diseased; avoid long standing; and use an elastic bandage of flannel or rubber, or an elastic stocking from the toes to the knee.

Radical treatment aims at obliterating the dilated veins and forcing the blood into the deeper veins, which, having the support of the muscles, seldom become varicose. There are several operations for

this purpose. (1) The use of harelip pins or needles passed beneath the veins and the application of thread in figure-of-8 form, compressing the vein between the pin and the thread. (2) Ignipuncture, passing a red-hot needle into the vein in various places, is recommended by Tillmanns. (3) *Phelps's method*—multiple subcutaneous ligation with catgut. (4) *Madelung's method*—excision of the entire varicose vein and its principal branches; suitable for cases of phlebitis from infection. (5) *Trendelenburg's method.* Ligation of the long saphenous vein at or near the saphenous opening; the vein is exposed by an incision, two ligatures are applied, and the vein is divided between them. It is the operation to be selected when the veins below are filled chiefly by descent of the blood from the femoral vein. To determine this, have the patient lie down till the vein becomes empty; place the finger firmly over the vein two or three inches below the saphenous opening, then allow the patient to stand again; the vein *above* the finger fills with blood. (6) *Schede's method*—suitable in cases free from infection and in those not suited for Trendelenburg's operation. Make a circular incision around the leg about four inches below the knee, dividing the skin and superficial fascia down to the deep fascia covering the muscles. All the superficial veins are divided by this incision. Tie each end of every cut vein with fine catgut, from twenty to sixty ligatures being usually required, and unite the edges of the wound. If the veins on the inner side of the leg are those chiefly affected, a *modified Schede* may be done, making the incision from the inner border of the tibia half around the leg on the inner side, dividing both the internal and external saphenous veins and their principal branches, leaving intact the outer semicircumference of the leg which contains comparatively few veins. Esmarch's bandage may be used, or the veins may be caught with forceps as they are successively exposed by a gradually extended incision.

FIG. 99.—Veins of the lower extremity: *a*, femoral artery; *b*, long or internal saphenous vein joining the femoral vein.

Diseases of Arteries.

ARTERITIS.

Arteritis, or inflammation of an artery, may be acute or chronic.

ACUTE ARTERITIS is rare, but may be caused by wounds, by ligation, by the lodgement of an infectious embolism, or by the extension of inflammation from adjacent tissues.

Pathology.—Any one of the coats may be affected, giving rise to the names *endarteritis*, *mesarteritis*, and *periarteritis*. The inflammatory process begins in the *internal* coat when caused by thrombosis or embolism and in the *external* coat when the cause is outside of the artery. There is infiltration with cells and an exudate of lymph which in simple cases is eventually absorbed, but infectious cases usually go on to suppuration, possibly with the formation of abscess and destruction of the arterial coats. If the thrombus break down, serious hemorrhage may result. Secondary hemorrhage is often caused by suppurative arteritis.

CHRONIC ARTERITIS, ENDARTERITIS, ATHEROMA, is a chronic inflammation of the *intima*, usually of the aorta or other large arteries, causing fatty degeneration, the formation of ulcers, and an increase in the amount of fibrous tissue with calcareous deposits.

Pathology.—While occurring most frequently in persons of advanced age, it is often seen in the middle-aged, and may affect comparatively young persons. The *causes* are traumatism, mechanical strain, syphilis, tuberculosis, chronic alcoholism, gout, rheumatism, Bright's disease of the kidney, or the result of old age,—a senile degeneration. The poor and miserable, as well as athletes and "high livers," are very liable to the disease. It begins with an infiltration and proliferation of cells in the deeper layers of the intima, gradually extending to the other coats, though occasionally it is limited to the intima. With the formation of new connective tissue the intima swells, and sometimes becomes so thick that it obliterates the lumen of the vessel,—*obliterating endarteritis*, often seen in the arteries of the brain. The new tissue develops in patches, making fibroid plaques or incomplete rings, seen around the origin of arteries from the main trunk. Fatty degeneration takes place, probably due to endarteritis of the vasa vasorum, and the atheromatous patches then appear as slightly projecting yellowish areas, sometimes covered by normal endothelium. Later the affected tissue softens and liquefies, forming "atheromatous abscess," and on discharge of its contents atheromatous ulcer is left. Lime salts are deposited in these ulcers or in the fibrous plaques or rings, forming

laminar, *annular*, or *tubular* calcifications. Atheroma bears an important relation to the pathology of aneurism.

Symptoms.—The condition can be readily recognized in the arteries of the extremities by the rigid, pipestem-like sensation when the finger is placed on the vessel. The formation of an arterial thrombus may cause gangrene of a limb, or obliterating *endarteritis* of the vessels in the brain may interfere with the cerebral functions.

Treatment.—Treat the disease, as syphilis, which causes the changes in the arteries. Caution against excesses of all kinds, especially violent exercise, lest rupture of an artery be produced. In suppurative arteritis the danger of hemorrhage should be recognized and provided for.

ANEURISM.

Aneurism is a blood-sac communicating with the interior of an artery, and composed of one or more of the arterial coats. This is *true* aneurism. *True* aneurisms are divided into tubulated, sacculated, and dissecting aneurisms. *False* aneurisms include arterial varix, cirsoid aneurism, aneurismal varix, varicose aneurism, and traumatic aneurism.

Tubulated or *fusiform* aneurism is one in which all three coats of the artery are dilated more or less equally around its circumference.

FIG. 100.—Fusiform aneurism.

The middle coat is degenerated; its muscular fibres separate or they may entirely disappear. It occurs in the thoracic, abdominal, and cranial cavities. It seldom ruptures or attains a great size, but its walls may give way on one side and permit the development of a *sacculated* aneurism.

The *sacculated* aneurism is one which develops from the side of an artery or from the wall of a *tubulated* aneurism. Its communication with the vessel is the narrowest portion of the sac and is called the

mouth. It may grow to be very large and the coats of the artery may all disappear except the intima, the other coats being composed of connective tissue organized from the surrounding structures.

The *dissecting* aneurism is one in which the intima has given way so that the blood escapes into the middle coat, which it dilates or dissects up for a distance along the artery, causing a dilatation of the external coat; or, coming in contact with an atheromatous patch, it may break through into the surrounding tissues, forming a false aneurism; or through the intima back into the lumen of the artery, forming a double tube of variable length.

FIG. 101.—Sacculated aneurism.

ETIOLOGY.—The causes of aneurism may be divided into *predisposing* and *exciting*. Under *predisposing causes* are: *Age*, from thirty to fifty being the most common period. *Sex:* Aneurism is seven times as common in males as in females. *Occupation:* Occupations which lead to hypertrophy of the heart or its increased action or to strain of special arteries predispose to aneurism; as athletes, soldiers, sailors, laborers, are those most frequently affected. Hunters, cavalrymen, and coachmen are more liable to aneurism of the popliteal artery. *Country:* It is said that more cases occur in Great Britain than in other countries. *Diseases* which cause atheroma or degeneration of the arterial tunics, as syphilis, alcoholism, chronic nephritis, acute rheumatism, and tuberculosis. *Situation of the Artery.* (1) Thoracic aorta. (2) Popliteal and femoral. (3) Abdominal aorta. (4) Carotid and subclavian. Stimson found 55 cases of aneurism in 22,197 patients, showing the frequency of aneurism to be about one in four hundred persons.

Exciting Causes.—Injury is the principal exciting cause, and may follow fracture, dislocation, or wounds which damage the arterial coats so that degeneration takes place and subsequent distention or rupture of one or more of the coats. Repeated strains cause gradual and progressive distention. Emboli may cause aneurism by plugging up an artery, and if infected with micro-organisms degenerative processes set in and the arterial walls are weakened so that dilatation occurs more readily.

PATHOLOGY.—It is only in *tubulated* aneurisms that all the arterial coats are found composing the walls of the aneurismal sac. In the *sacculated* aneurism the middle and external coats soon give way and are replaced more or less completely by a fibrous coat produced by organization of the surrounding connective tissue. In those aneurisms

whose shape permits the collection of blood to one side of the main current, coagulation and deposits of fibrin take place. The layers of fibrin in the periphery of the sac, most distant from the blood current, are firm and better organized than in portions near the mouth of the sac. In sacculated aneurism fibrin is deposited rapidly, the rapidity depending on the relation of the size of the mouth of the sac to the blood current, the smaller the mouth and the greater the obstruction to the flow of blood into the sac the greater the tendency to the formation of fibrin; therefore in fusiform aneurism there is seldom a deposit of fibrin.

Spontaneous cure occasionally takes place: (*a*) By the gradual deposit of fibrin in the sac until it is filled up, sometimes obliterating the artery. (*b*) By embolism, a clot being washed out of the sac and plugging the efferent artery so that the current is completely arrested. (*c*) Pressure from the size and weight of the sac may retard or completely arrest the current and permit coagulation or fibrin deposits. (*d*) Acute inflammation of the sac may result in coagulation and solidification of the sac.

Death may result: (*a*) From rupture of the sac,—the aneurism extending to the skin, œsophagus, trachea, pleura, pericardium, peritoneum, or intestine. Death may ensue from repeated small hemorrhages or from one severe hemorrhage. Rupture into the trachea, pleura, or pericardium may cause immediate death from suffocation or interference with the heart's action. (*b*) *Pressure* on important organs, as the trachea, bronchi, lungs, œsophagus, thoracic duct, spinal cord, sternum, ribs, and nerves. (*c*) *Septicæmia* and *pyæmia* from acute inflammation and suppuration of the sac. (*d*) *Embolism*, a small clot being detached and lodging in the brain. (*e*) As a result of *gangrene* of an extremity from obstruction of the blood supply.

Signs and Symptoms of Aneurism.—(*a*) *Pulsation.*—A distinct, *expansile* pulsation synchronous with the action of the heart is felt when the aneurism is taken between the finger and thumb of one hand. The expansile character is shown in the tendency to separate the finger and thumb with each pulsation. After coagulation or the deposit of fibrin in the sac, the tumor is firm and resisting and pulsation is indistinct, may be lost, or certain points over the sac may give more distinct pulsation than others.

(*b*) *Effects of Pressure.*—Pressure on the cardiac side diminishes, pressure on the distal side increases, the size of the tumor, while pressure on the cardiac side diminishes or stops the pulsation. If coagulation have taken place the tumor is not affected by pressure.

(*c*) *The Bruit.*—On placing a stethoscope or the ear over an aneurism, a blowing, rasping noise is heard, transmitted along the

artery beyond the sac. This sound is produced by the blood rushing into and out of the sac through its mouth, or by the change in calibre of the vessel, as in *fusiform* aneurism. Coagulation in the sac abolishes the bruit or changes its character.

(*d*) *The Pulse.*—The pulse beyond the tumor may be delayed or weakened as compared with the corresponding artery on the other side, and the sphygmographic tracings of the pulse on the two sides show a marked difference.

(*e*) *Œdema* of a *limb* may result from pressure on the veins.

(*f*) *Gangrene* is sometimes caused by the pressure of the tumor, or it may be the result of embolism.

(*g*) *Pain.*—Pain varies in degree and character. It may be slight at first, but after coagulation or solidification it may be severe. It is sharp, lancinating, when it presses on the soft tissues and the nerves, or aching and boring when the bone is involved. Pressure on special organs often gives valuable symptoms; pressure on the trachea or recurrent laryngeal nerve causes dyspnœa, brassy cough, altered voice or paralysis of one of the vocal cords; on the œsophagus or the phrenic nerve, hiccough. Aneurism of the arch of the aorta sometimes gives rise to "tracheal tugging" (Surgeon-Major Porter). It is brought out by taking hold of the cricoid cartilage when the patient is sitting with the neck relaxed, and putting the trachea slightly on the stretch. If there is aneurism of the arch, a distinct tugging is felt with each pulsation of the heart.

DIAGNOSIS.—The diagnosis must be made from abscess, from pulsating cancers and sarcomas, from erectile tumors, from hæmatocele of the neck, and from abscess near an artery. In *abscess* there are usually signs of inflammation. If situated above an artery it may have a communicated pulsation, but it is simply an up-and-down motion, without the *expansile* character of aneurism; pressure on the cardiac side of the artery would not affect the size of an *abscess;* and, most important, there is no *bruit* on auscultation.

DURATION.—As a rule, the growth of an aneurism is slow, occasionally rapid, being influenced by the size and condition of the sac, size of the mouth, coagulating tendency of the blood, location of the aneurism, the patient's habits and manner of living, and the treatment employed.

TREATMENT.—The object is to effect solidification of the sac by coagulation and deposit of fibrin. This is done by adopting measures for slowing the action of the heart and increasing the coagulating tendency of the blood. The treatment is divided into *medical* and *surgical.*

Medical Treatment.—Langenbeck's method, hypodermatic injec-

tions of ergotine, has been successful. The Valsalva-Tufnell-Balfour method is as follows: Keep the patient in bed at least three months; restrict the diet, Tufnell fixing the amount at ten ounces of solids and six ounces of fluids in twenty-four hours; use lactucarium and opium to induce sleep and relieve pain and an occasional purgative for reducing the watery portion of the blood, and give iodide of potassium. This method is especially applicable when the aneurism is not suitable for surgical treatment.

Surgical Treatment.—The surgical methods of treating aneurism may be divided into (1) compression, (2) ligation, and (3) miscellaneous procedures.

1. *Compression* may be: (*a*) *Instrumental*, by means of a tourniquet, Skey's or other instrument, which produces pressure at only two points,—namely, on the artery and the part of the limb or body opposite. This may be kept up from one to several days or until pulsations cease, when it should gradually be relaxed and removed. The instrument should be well padded to prevent bruising of the tissues. (*b*) *Digital* pressure was first employed in 1848. It is applied by means of relays of assistants, who press the artery against the bone by means of the thumb. The pressure must be kept up without intermission from one to two days or until pulsations cease. The assistants should relieve one another about every fifteen minutes. This is one of the safest and best methods of treating aneurism. Instead of the fingers or thumbs a bag of shot may be used, the bag being suspended by rubber tubing so as to make pressure on the artery. (*c*) *Esmarch's bandage.* Under anæsthesia apply the rubber bandage firmly from the extremity up to the aneurism, loosely over the aneurism in order to leave enough blood in the sac for coagulation, then again tightly above to where the rubber tube is applied. Keep on for from one to two hours or during the anæsthesia, then remove and apply a tourniquet to the artery to prevent washing out the coagulum in the sac. Keep this on for from twelve to twenty-four hours, gradually relaxing it before removal. Contraindications to this method are inflammation of the sac, marked atheroma of the arteries, and renal disease. (*d*) *Flexion of the joint* may be used for aneurisms occurring near the elbow or knee. The limb is first bandaged, then flexed and again bandaged, so as to retain it in this position for several days. This slows or weakens the blood-current and permits clots to form, or it may detach an embolus which plugs the afferent vessel. It is not suitable in large or inflamed aneurism or if there is much œdema of the extremity.

2. *Ligation.*—(*a*) The "old operation," or the operation of Antyllus, used in the fourth century, consists in ligating the artery on both

sides of the aneurism, laying open the sac and turning out the clot. A better method, (*b*) *extirpation* of the aneurism, introduced about the same time as the old operation, but since revived under aseptic precautions, has given excellent results. Two ligatures are applied to the artery well above and two ligatures well below the aneurism, the artery is divided on both sides, and the aneurism is completely dissected out. Advantages are, less danger of emboli, which might cause gangrene, of secondary hemorrhage and sepsis, and diminished mortality. It is especially suitable for traumatic aneurisms. (*c*) *Anel's method*, devised and practised by Anel in 1710, consists in tying the artery *near* the aneurism on its cardiac side, with the object of causing collapse of the tumor. This method is faulty in

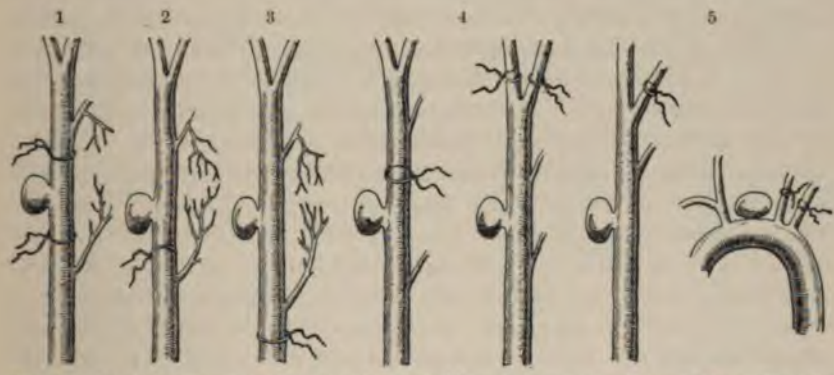


FIG. 102.—Ligation for aneurism: 1, Antyllus's or old operation; 2, Anel's method; 3, Hunter's method; 4, Brasdor's method; 5, Wardrop's method.

two respects: First, the portion of the artery to which the ligature is applied, being near the aneurism, is often diseased, and gives way, with secondary hemorrhage; and, second, on account of the proximity of the ligature to the aneurism sufficient blood may not be left in the sac for coagulation. (*d*) *Hunter's Method.*—In 1735 John Hunter improved Anel's method by applying the ligature on the same side, but far enough from the aneurism to get healthy tissue and allow collateral branches to arise and supply sufficient blood in the sac for coagulation. (*e*) *Brasdor* ligated the artery on the distal side near the tumor, completely arresting the circulation. (*f*) *Wardrop* ligated the artery or one of its terminal branches on the distal side of the sac, but at a distance so that the circulation is not completely arrested. (*g*) *Amputation* may be necessary for ruptured aneurism, for frequent hemorrhages threatening life, for gangrene, or for caries of the bone or involvement of the joints.

3. *Miscellaneous Methods.*—(*a*) *Galvanopuncture.*—In order to produce coagulation the galvanic current of five or six milliamperes is passed through the sac by means of two insulated needles introduced into opposite sides so as not to come in contact with one another. (*b*) *Acupuncture.*—Introduce a number of fine needles or pins into the sac in such a manner as to cross one another, and leave for several days or till a clot forms. (*c*) *Macewen's Method.*—Endeavor to induce the formation of white thrombi by *teasing* the inner surface of the sac wall with a long aseptic needle. (*d*) *Manipulation, Massage, or Kneading.*—The object of this method is to detach a portion of the clot in order to plug up the efferent vessel, on the principle of Brasdor's method of ligation. It should not be used in aneurism connected with the arteries leading to the brain, as fatal embolism might result. (*e*) *Coagulating* or other injections of iron, tannin, acetate of lead, and gelatin have been injected into the sac of an aneurism in order to produce coagulation, but the method is dangerous and is not often used. (*f*) The *insertion of wire, catgut, silk,* or *horsehair.* In this method from two to thirty yards of fine wire or the other materials mentioned are introduced by means of a fine-pointed cannula into the sac and left, in order to produce coagulation. Wire is the material usually selected, and was first used by Moore in 1864. The wire may be silver, silver and copper alloy, steel, or gold. After its insertion a galvanic current not exceeding eighty milliamperes in strength is used by attaching the positive pole to the end of the wire in the sac and the negative pole to a metal plate applied to the back of the patient and kept up from a few minutes to an hour. This is called the *Moore-Corradi* method. Hunner has reported fourteen cases treated by Moore's method (simple introduction of wire), with two cures, and twenty-three cases by the Moore-Corradi method with four cures, nine improved, with prolongation of life, and in ten death was probably hastened. The cases treated were aneurism of the thoracic or abdominal aorta.

False Aneurisms.

1. Arterial varix is an affection of an artery corresponding to varix of a vein, and is usually seen in small or medium-sized arteries, as the superficial temporal, posterior auricular, occipital, facial, radial, and ulnar. When a number of such arteries form a plexus with one another, the result is cirsoid aneurism.

2. Cirsoid Aneurism, Aneurism by Anastomosis, Racemose Aneurism, Plexiform Angioma, or Pulsating Erectile Tumor.—This is really a blood tumor (see Angioma).

Symptoms.—It appears as a pulsating, bluish, compressible tumor

of irregular shape. In some cases the surface temperature over the tumor is elevated. The skin and walls of the vessels may become thin, and ulceration with alarming hemorrhage sometimes occurs.

The *diagnosis* from true aneurism is made by its situation, the doughy sensation, and the number of vessels involved.

Treatment.—A single varicose artery may be obliterated by ligation. Cirsoid aneurism is best treated by excision after ligation of all the afferent vessels.

3. ARTERIOVENOUS ANEURISM is an unnatural communication between an artery and a vein, and includes two forms,—(*a*) *aneurismal varix* and (*b*) *varicose aneurism.*

ANEURISMAL VARIX is the direct or immediate communication of an artery with a vein. The blood passes freely into the vein, whose coats become dilated from the effects of the strong arterial current and the interference with the venous current. The condition is seen in situations where large arteries and veins lie close together, as in the neck, thigh, and arm, as a result of stab or gunshot wounds involving both artery and vein.

FIG. 103.—Arteriovenous aneurism: *a*, aneurismal varix; *b*, varicose aneurism.

Symptoms.—An oblong, pulsating, expansile tumor is seen, with a peculiar bruit which has been compared to the purring of a kitten or the buzzing of a fly in a paper bag. Compression of the artery on the cardiac side causes the tumor to disappear and the pulsations to cease. The condition may last for years without serious inconvenience, but the veins towards the periphery are apt to become dilated and œdema of the extremity may develop.

VARICOSE ANEURISM is a condition similar to aneurismal varix, but the vessels communicate with each other through the medium of a sac situated between them. It is the result of injuries affecting both artery and vein, but, instead of the two vessels uniting, they are separated by the formation of a traumatic aneurism between them communicating with both.

Symptoms.—The tumor is more sharply defined and the bruit softer in character than in aneurismal varix; otherwise the symptoms of the two conditions are practically the same.

Treatment.—In *aneurismal varix*, if there is no inconvenience, enlargement, œdema, or tendency to ulcerate, a simple compress over the tumor is sufficient. Otherwise, ligate the artery above and below the point of communication with the vein. Because of its tendency to increase in size and finally to rupture, *varicose aneurism* should be operated on, either by ligation of both vessels and excision of the sac or by ligation of the artery alone above and below the sac. Digital compression on the cardiac side may be tried, but no pressure must be made on the sac, lest ulceration occur.

4. Traumatic Aneurism, False Aneurism, Arterial Hæmatoma.—A *traumatic aneurism* is a collection of blood in the tissues communicating with a wound in an artery. In recent cases there is no sac, the boundary being the surrounding tissues, which may be dissected up over a large area by the blood following the lines of least resistance, giving rise to the *diffuse* form of traumatic aneurism. In old cases a *sac* may exist, but it is not derived from the coats of the artery; the escaped blood excites a plastic inflammation in the surrounding tissues, resulting in a more or less complete sac of fibrous tissue which encloses the effused blood. This is the *circumscribed* form of traumatic aneurism. The *causes* are stab or gunshot wounds which injure the arterial coats so that they slough after the external wound has healed; severe contusion which may divide an artery without breaking the skin; or laceration of an artery in attempts to reduce old dislocations, as of the shoulder. A traumatic aneurism of the femoral artery occurred in the author's practice thirty-eight days after a gunshot wound of the thigh.

Symptoms.—In the *circumscribed* form a tumor with bruit, thrill, and expansile pulsation may be detected; in the *diffuse* form there is a rapidly growing tumor of irregular shape covering a larger area with less defined borders. In either form there is a history of traumatism, followed by swelling, pain and numbness of the limb, weakness or absence of pulsation in the artery beyond the swelling, œdema and discoloration from venous obstruction, and sometimes gangrene. The last three symptoms are apt to occur in the diffuse variety of traumatic aneurism.

Diagnosis.—This should be made from *abscess* by the thrill, the pulsation, and bruit, or exploration with the hypodermatic needle. Abscess and aneurism may coexist.

Treatment.—A *circumscribed* traumatic aneurism of slow growth, with little interference with the circulation, may be cured by elevation of the part and pressure on the proximal side of the artery. In the *diffuse* form, on account of the risk of gangrene setting in, an Esmarch's bandage should be applied, the circulation controlled, the

tumor opened, the clots turned out, and both ends of the artery tied. Should the aneurism be connected with an artery where the circulation cannot be reached above or controlled by tourniquet, as the carotid or iliac, the operation is difficult and dangerous. A careful dissection should be made down to the walls of the sac, in which an opening should be made just large enough to admit the surgeon's finger. The opening in the artery is then sought with the finger, which may be guided by feeling a jet of warm blood. Compression is made with the finger on the opening in the artery until the communication with the sac can be enlarged, the clots turned out, and the artery secured with hæmostatic forceps and ligated above and below the sac. The appearance of *gangrene* as a result of traumatic aneurism requires amputation about the level of the injury to the artery.

Treatment of Special Aneurisms.

Aortic and Innominate Aneurisms.—The Valsalva-Tufnell-Balfour treatment should be tried, but if this fail, operative measures may be adopted. For *aneurism* of the *ascending arch* or of the innominate artery the operation of Brasdor or Wardrop may be used,—viz., the ligation of the subclavian and carotid on the right side or of either of these vessels alone. If the aneurism spring from the *transverse* portion of the arch, the same method may be used on the left side. When the *abdominal* aorta is affected compression of the aorta by Skey's tourniquet may be tried, the aorta may be ligated, or the Moore-Corradi method can be used. The last procedure may be a desirable form of treatment in any of these aneurisms. Wyeth reports 7 cases of simultaneous ligation of the carotid and subclavian on the right side for *aortic* aneurism, showing 5 recoveries from the operation with evident improvement. In 9 cases the carotid artery alone was tied, with 7 recoveries and 2 deaths. All the patients were much improved and one of them was living five years after the operation. For *innominate* aneurism, 12 cases were treated by simultaneous ligation of the carotid and subclavian arteries, with more or less perfect recovery in 5 cases and death in 7. In 3 cases the carotid and subclavian were tied at different times, with one cure and death on the twenty-first and forty-fourth days respectively in the other two cases. Fourteen cases of innominate aneurism were treated by ligation of the carotid alone (the single distal operation), with one single cure. In 4 cases the subclavian alone was ligated in its third division, with recovery from the operation in every case, the patients living from several months to two years. For aneurism involving *both* the *innominate* artery and the arch of the *aorta*, the double distal

operation was performed in 8 cases, with 3 deaths and 2 recoveries, the other 3 not being materially benefited by the operation. For the same kind of aneurism, in 6 cases one of the carotids was tied, with the result that 5 of the patients died within a few days after the operation, 3 of the deaths being due to the pressure effects of the consolidated aneurism. For aneurism the *abdominal aorta* has been tied 12 times, with 12 deaths; 1 patient lived two and a half days, 1 ten days, 1 twenty-nine days, and 1 forty-eight days. The one living forty-eight days died from hemorrhage due to the ligature (silk) cutting the vessel at the point of ligation.

CAROTID ANEURISM.—If medical treatment fail, use pressure or the ligature. Pressure is often painful and cannot be well carried out. When the location of the aneurism will allow it, Hunter's operation should be performed, using catgut or kangaroo tendon for the ligature. When there is not room enough to apply the ligature on the cardiac side of the tumor, the distal method (Brasdor or Wardrop) should be used.

Wyeth reports 106 cases treated by ligation on the cardiac side, with 69 recoveries; and 7 cases treated by the distal method of ligation, with 2 deaths from hemorrhage and 5 improved or cured.

Aneurism of the *external* or *internal* carotid should be treated if possible by ligation on the cardiac side of the vessel involved. Both carotids should never be ligated at the same time.

Dangers.—Syncope, cerebral embolism with aphasia or paralysis, secondary hemorrhage, or suppuration may follow the operation of ligation of the carotid artery.

SUBCLAVIAN ANEURISM.—May be *constitutional*, alone or in connection with or followed by *ligation* or *compression*. There is great diversity of opinion as to the best surgical treatment. *Pressure* directly over the aneurism when it is small; *massage*, *pressure*, or *ligation* on the distal or cardiac side; *excision* and *amputation*, have all been tried. According to Wyeth and Burrell, of 29 cases treated by ligation of the *innominate singly* or with the *carotid* and *vertebral*, 25 died from the immediate effects of the operation and 4 recovered; 15 cases treated by ligation of the *innominate alone* were all fatal; and 8 cases of ligation of the first portion alone of the right *subclavian* were all fatal. Souchon reports 15 cases of *traumatic aneurism* of the *right subclavian* artery treated by ligation of the *innominate*, or of the *subclavian* in one of its divisions, or by the old operation of ligating both sides of the sac and incision of the sac, with 4 recoveries; 3 of these being cases in which the sac was excised and the clots turned out. Of 17 cases of traumatic aneurism of the *left* subclavian reported by Souchon, treated by ligation of the first, second, or third divisions, and in one case by

amputation at the shoulder-joint after ligation, there were 15 cures and only 2 deaths. According to Wyeth, ligation of the axillary artery alone on the *left* side has been done in 3 cases, all fatal; and amputation at the shoulder-joint 5 times, with 2 recoveries. Of 113 cases of *subclavio-axillary* aneurism treated by ligation of the third division of the subclavian artery, there were 47 deaths. Halsted excised a subclavio-axillary aneurism after ligation of the first portion of the left subclavian and the axillary artery, with excision of a portion of the clavicle. The patient recovered. Five cases treated by *direct pressure* on the aneurism resulted in 4 recoveries and 1 death. Six cases treated by *massage* or *kneading* resulted in 3 recoveries and 3 deaths. Fourteen cases treated by the Valsalva method gave 7 recoveries, 5 deaths, and 2 improved. Twenty-two cases in which *no treatment* was used gave 18 deaths and 4 cures.

AXILLARY ANEURISM may be treated by digital or instrumental *compression* of the third portion of the subclavian where it passes over the first rib; by *ligation* of the third portion of the subclavian; by the *elastic bandage* applied to the arm with pressure on the cardiac side of the sac in addition; by *ligation* of the artery on both sides of the sac and excision; or by amputation at the shoulder-joint.

ANEURISMS OF THE ARTERIES OF THE EXTREMITIES may be treated (1) by digital or some other method of *compression* on the cardiac side; (2) by *flexion* of the *limb*, when near joints; (3) by *Hunter's method* of ligation; (4) by *ligation* on *both sides* with excision of the tumor.

Wounds of Blood-vessels.

HEMORRHAGE.

Wound of a blood-vessel is usually followed by the escape of blood—hemorrhage—either externally or into the subcutaneous tissues. Predisposing causes of hemorrhage are circumstances which change the normal condition of the blood in certain ways, as cirrhosis of the liver, jaundice, poisoning by phosphorus; or vicariously when a normal discharge of blood is suppressed.

CLASSIFICATION.—According to the source of the blood hemorrhage is divided into *four varieties:* (1) *Arterial hemorrhage*, when the blood comes from an artery, as shown by its bright-red color and by its coming out in jets with each pulsation of the heart; (2) *venous hemorrhage*, characterized by a steady flow of dark-colored blood; (3) *capillary hemorrhage*, indicated by a steady oozing from many points, without the jets seen in arterial hemorrhage or the steady flow from a single vessel which occurs in venous hemorrhage; (4) *parenchyma-*

tous hemorrhage, which resembles capillary hemorrhage, but is usually more copious and occurs in those tissues in which the arteries communicate directly with the veins without the medium of capillaries, as in the brain, the spleen, and the erectile tissues.

According to the *time* of occurrence after the reception of an injury hemorrhage is divided into *primary*, *intermediate*, and *secondary*. *Primary* hemorrhage occurs immediately after the receipt of a wound. *Intermediate* hemorrhage occurs a short time after the receipt of an injury and within the first twenty-four hours; it is sometimes called *reactionary* or *recurrent* hemorrhage, because it may occur from displacement of a ligature or clot owing to increased force of the heart during reaction. *Secondary* hemorrhage occurs at any time after the first twenty-four hours. It is most frequent about the seventh to the tenth day, and may be caused by the separation of a ligature, by the establishment of collateral circulation when only one end of an artery has been tied, by suppuration, or by sloughing of the wall of an artery or vein from the effects of the original injury.

Symptoms of Hemorrhage.—In open wounds the symptoms are evident in the visible escape of blood. Subcutaneous hemorrhage may be indicated by discoloration of the skin or the presence of a tumor in the subcutaneous tissue. The *constitutional* symptoms depend on the amount of blood lost. Strong adults in health and women during the puerperal state bear the loss of blood very well; very young or very old persons bear it poorly. The pulse is weak and rapid; the respirations frequent and irregular, and there may be great dyspnœa; the temperature is subnormal; the face pale, the lips and finger-nails blue; there are dilatation of the pupils, profuse perspiration, coldness of the extremities, disturbance of sight and hearing, frequent attacks of syncope, great thirst, and restlessness; sometimes delirium comes on and a semiconscious or unconscious condition with collapse, and death may occur in this condition.

Treatment.—In many cases the unaided efforts of nature are sufficient to arrest hemorrhage. Coagulation is aided by exposure to the air and by the retraction of the cut ends of the blood-vessels. When an artery or vein is divided the vessel retracts within its sheath, while the middle and internal coats also retract, thus forming an obstruction to the escape of blood and favoring the tendency to the formation of a clot. This process may be materially aided by the reduced force of the heart's action as a result of syncope. The nature of the injury is also important, as vessels severed by a crushing or twisting force are less apt to bleed than when cleanly divided by a sharp edge. The treatment may be divided into *local* and *constitutional*.

Local Treatment.—Hæmostasis is induced by: (*a*) Some method of compression. (*b*) The application of heat or cold. (*c*) Ligation of the bleeding vessel. (*d*) Torsion. (*e*) Use of the actual cautery. (*f*) Acupressure. (*g*) The application of styptics. (*h*) Position, as the elevation of the part. *Compression* is used when the bleeding is slight or of the capillary or parenchymatous variety, and may be digital or applied by means of a compress of gauze held in place by a moderately tight bandage. *Ligation* is the method to be used when the blood comes from an artery or a large vein. Both ends of the artery should be tied, and if the division of the vessel is not complete it should be made so. Wounds in large veins may be closed by suture or lateral ligature. *Torsion* is a good method for small and medium-sized arteries. The vessel is seized transversely with one pair of forceps and held steady, while with the second pair the end of the vessel is grasped and twisted, making two or three complete turns on the axis of the vessel. Arteries as large as the femoral have been secured in this way after amputation, but it is not so safe a method as ligation. *Acupressure* is seldom used. It may be preferred when it is desirable to cut off the blood supply from a part without cutting down on the artery and securing it in other ways. A needle or hare-lip pin is introduced through the skin beneath the blood-vessel and made to project through the skin on the other side. A loop of thread is then thrown over the two ends of the pin so as to compress the blood-vessel between the thread and the pin. The *actual cautery* may be used in cases where ligation or compression is difficult or impossible, as in operations on the liver. Hot water is excellent to arrest oozing from stumps.

Constitutional Treatment.—If there are symptoms of depression or collapse, administer stimulants, put the patient in the recumbent posture with the head low to prevent cerebral anæmia, protect the body and limbs with warm blankets, apply hot-water bottles, and give cardiac stimulants, as aromatic spirit of ammonia, strychnine, digitalis, nitroglycerin, whiskey, brandy, ether, by the mouth or hypodermatically, enemata of hot water, hot salt solution, turpentine, or brandy. When much blood has been lost and life is threatened, inject salt solution into the veins. The use of Esmarch's bandages to the extremities is recommended in some cases, in order to force the blood into the body and brain. When *reaction* takes place, there may be a slight febrile disturbance, probably due to the absorption of *fibrin ferment*, or a condition of anæmia may be established. The *after-treatment* consists in keeping the patient quiet and free from disturbance, the judicious use of food, and iron for anæmia.

Resection of Blood-vessels.—Murphy recommends in suitable cases

resection and end-to-end anastomosis of large arteries and veins. The technique of the operation is as follows: The circulation in the vessel is controlled by means of forceps with blades protected by rubber. The injured portion of the vessel is resected, the distal portion is split for a short distance in order to permit invagination of the proximal part, three fine silk sutures, each end of which is armed with a cambric needle, are introduced at equidistant points through the middle and external coats of the proximal portion of the vessel. The needles are passed into the distal portion to a point about a third of an inch above the end, where they are made to penetrate the walls of the vessel and emerge externally. By traction on the ends of the sutures the proximal is drawn into the distal portion of the vessel and the ends of the sutures are tied. An additional row of sutures one-sixteenth of an inch apart should be introduced, uniting the end of the distal portion to the external and middle coats of the proximal portion all around. Care should be taken that the union is close enough to prevent hemorrhage. Murphy has performed this operation successfully on many dogs and other animals and once successfully on a man, resecting half an inch of the femoral artery for gunshot wound of that vessel.

HÆMOPHILIA.

Hæmophilia, or the *hemorrhagic diathesis*, is the name given to a tendency to excessive hemorrhage, occurring spontaneously or as the result of traumatism. It occurs, as a rule, in early life, before the second year, more frequently in males, and is said to be inherited, usually through the mother. The hemorrhage comes from the capillaries and may be subcutaneous, forming large hæmatomata, or purpuric spots under the skin or mucous membrane, often accompanied with a form of arthritis. It may result from slight injuries, as a scratch of the skin, a bite of the tongue, the extraction of a tooth, or follow the application of leeches or blisters; or it may occur spontaneously as epistaxis. No satisfactory explanation has been given of the cause of the condition. Some think it due to a deficiency of chloride of calcium in the blood, resulting in a diminished tendency to coagulation, but examinations have failed to show any important abnormality either in the blood or the blood-vessels.

TREATMENT.—No operation should be done on a "bleeder" unless absolutely necessary. Elevate the part and apply hot compresses, solution of gelatin, blood from a healthy person, antipyrin, alum, gallic or tannic acid, acetate of lead, the actual cautery, or extract of suprarenal capsule. As *constitutional* treatment chloride of calcium is recommended for its specific effects.

The Lymphatics.

WOUNDS of the lymphatics occasion little or no trouble, unless followed by infection or the thoracic duct be involved. The *thoracic duct* may be wounded in surgical operations about the neck, or may be ruptured as a result of traumatism.

Symptoms.—The symptoms, if occurring during the course of a surgical operation, would be the appearance of a milky fluid. When rupture occurs internally the symptoms are caused by the accumulation of chyle in the pleura, mediastinum, or abdominal cavity. The *diagnosis* can be made by aspiration and observing the character of the fluid. Rapid emaciation from inanition is an important symptom.

Treatment.—For wounds of the duct in the neck use packing, suture, or forceps. Nine cases thus treated resulted in eight recoveries (Keen). When *chylothorax* or *chylous ascites* follows rupture of the duct, little can be done except to withdraw the fluid as soon as it occasions serious symptoms. It has been suggested by Agnew that in wounds of the thoracic duct no food should be given for several days, in order to avoid distention of the duct, which might interfere with the healing process.

LYMPHANGEITIS, OR ANGIOLEUCITIS, is inflammation of the lymphatic vessels. The varieties are *reticular* and *tubular*, the former indicating inflammation limited to the fine network of lymphatic vessels rather than the principal vessels; the latter inflammation of the principal trunks.

Causes.—The most frequent cause is microbic infection, which enters through a wound or through the unbroken skin or mucous membrane. Other causes are the effects of chemicals, burns, and the use of the Roentgen ray.

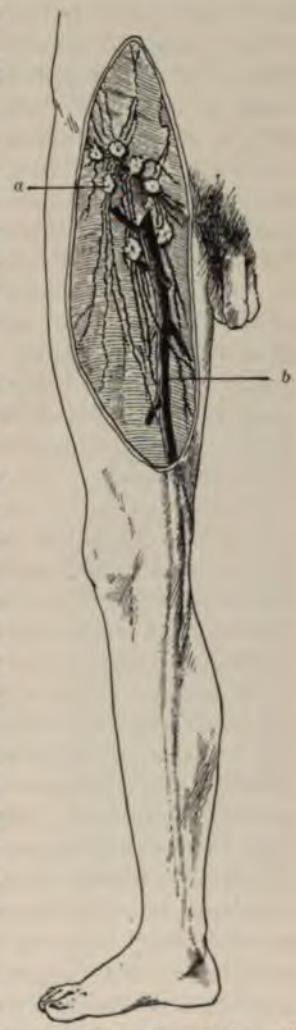


FIG. 104.—Lymphatics and veins of the groin and thigh: *a*, glands; *b*, internal saphenous vein. (After Gray.)

Symptoms.—*Reticular* lymphangeitis appears in the form of cir-

cumscribed, red, œdematous patches, which may be tender to pressure, with a tendency to spread. *Erysipeloid* and *erysipelas* are examples. *Tubular lymphangeitis* begins as such or results from the extension of reticular lymphangeitis into the main trunks. It denotes a greater degree of virulence, and is indicated by faint red lines, sometimes cords perceptible to the touch, running up the limb in the direction of the lymphatic glands. Thrombosis in the vessels may take place, with œdema, infection of the glands, metastatic abscesses, and the usual symptoms of septicæmia. In mild cases there is little fever, and the glands are not perceptibly involved.

The *treatment* is prophylactic and curative. Prophylactic treatment consists in efficient antiseptic treatment of all wounds, however small. After the disease appears, if a wound be present it should be thoroughly cleansed and disinfected and gauze wet with hot antiseptic solutions, such as bichloride 1 to 2000, or boracic acid (saturated solution), should be applied to the affected area. If suppuration threaten or occur, early and free incisions must be made. Œdema remaining after subsidence of the inflammation may require treatment by massage and bandaging. Constitutional remedies are important, as the disease is more apt to occur in those who are physically debilitated.

Conditions due to Obstruction of the Lymphatic Vessels.—The lymphatic vessels may be obstructed by various morbid processes, as inflammation, the presence of morbid growths or parasites, which interfere with the lymph current and produce rupture of the vessels, varicosities, or an abnormal growth of connective tissue in the part affected.

A frequent cause of lymphatic obstruction in tropical and semi-tropical countries is the nematoid worm called *filaria sanguinis hominis*. According to Manson, the adult female worm is a long, slender, hair-like animal, three inches in length but only one-hundredth of an inch in breadth. The male is much smaller. The adult worm lives in the lymphatics, where she produces innumerable embryos, which enter the blood current. The embryos are about one-ninetieth of an inch in length and of the diameter of a red blood-corpuscle, and are contained within a sheath, which, however, does not interfere with their wriggling movements. A remarkable thing is the fact that the embryos are only found in the blood while the host is at rest, —that is, during the night. But if the habits are reversed and the host sleeps during the day instead of night, the parasites are then found during the day. The obstruction in the lymphatic vessels is supposed to be caused by the adult worms or the ova. The life history of the parasite is not thoroughly understood, but it is supposed

that the embryo is taken into the body of the mosquito in the blood abstracted from one having the parasite. The mosquito in a short time dies and falls into the water, in which the embryos are released and may be taken into the system of any one drinking the water. Here they probably penetrate the tissues and enter the lymphatic vessels, where they become fully developed.

Lymphœdema is a hard, œdematous condition of the skin and subcutaneous tissue caused by obstruction to the lymph current, and is often the beginning of elephantiasis.

ELEPHANTIASIS.—*Elephantiasis Arabum, Barbadoes leg*, is hypertrophy of the skin and subcutaneous tissue, usually affecting the lower extremities, scrotum, penis, or labia, and caused by obstruction in the lymphatic vessels, often by the presence of the filaria sanguinis hominis. It is found most frequently in tropical countries, as India and Barbadoes, but may occur in other countries and is sometimes seen in the United States. The blood-vessels are increased in number and size, but the muscles waste away. The interstices are filled with an albuminoid substance, the papillæ of the skin are enlarged, and the periosteum and bone sometimes take part in the abnormal growth.

FIG. 105.—Elephantiasis in a Porto Rican boy.

Symptoms.—Elephantiasis may begin after several attacks of erysipelas or lymphœdema, each attack leaving the connective tissue thicker and more indurated. The skin becomes hard and coarse, ulcers form, there are repeated attacks of lymphangeitis, so that the skin and subcutaneous tissues sometimes attain a thickness of several inches, and with the hard, roughened appearance have a strong resemblance to the leg of an elephant,—hence the name. The disease usually begins below the knee, but may extend to the thigh. When the scrotum is affected an enormous tumor, reaching below the knees, may be formed. One or both legs may be involved, and sometimes other parts of the body, as the neck or upper extremities. The course of the disease is slow, extending over a period of many years, with no tendency to spontaneous recovery. A form of congenital elephantiasis is said to be produced by the constriction of amniotic bands or a misplaced cord, causing lymphatic obstruction with connective-tissue hyperplasia and the usual appearance of elephantiasis in the extremity or part affected.

Treatment.—Rest and elevation of the part and the use of a rubber bandage are sometimes followed by improvement. Ligation of the main artery of the limb has been practised at times with benefit; at other times it has been a failure. As a last resort amputation may be done. When the hypertrophied tissues form lobulated masses they may be excised. The great danger of the operation is hemorrhage, which may to a great extent be prevented by the use of the elastic bandage and by the ligation of all vessels as soon as cut.

LYMPHANGIECTASIS is a dilated, knotty, varicose condition of the lymphatic vessels corresponding to varix of the veins. The condition is seen most frequently on the genitals or inner side of the thigh or anterior wall of the abdomen. The varicose lymphatics occur as soft, elongated swellings in the skin, and may rupture, forming a *lymph fistula*, with a flow of lymph,—*lymphorrhagia*, or *lymphorrhœa*.

CHYLOCELE is an accumulation of a milky fluid in the tunica vaginalis testis, corresponding to hydrocele. It is caused by rupture of one or more lymphatic vessels. The diagnosis can only be made by withdrawing some of the fluid for examination.

The *treatment* is the same as that for hydrocele.

CHYLURIA is the presence of a milky fluid, or chyle, in the urine. It may be intermittent, and is sometimes attended with symptoms of discomfort or general debility. The urine readily coagulates, but soon decomposes. The *cause* is probably the filaria producing obstruction and the rupture of lymphatic vessels into some part of the urinary apparatus.

Treatment.—But little can be done in the way of treatment except to support the strength of the patient by means of tonics and proper food. Should the lymph coagulate in the bladder and cause obstruction, it may be removed by the injection of a warm solution of bicarbonate of sodium, as recommended by Hamilton.

MACROMELIA.—According to Gerrish, the condition of monstrous growth of one or more members, as the fingers, toes, foot, tongue, and lips, without other special symptoms of lymphatic disease, is due to excessive nutrition caused by obstruction to the lymph current. The cause of the disease is not known and the treatment is excision or amputation.

LYMPHADENITIS.—Inflammation of the lymphatic glands is caused by the entrance of a microbic or other irritant by way of the lymphatic vessels. The irritant provokes an accumulation of leucocytes and proliferation of cells with resulting enlargement of the gland. The inflammation may be mild or severe, depending on the nature and the quantity of the infectious agent and the ability of the tissues to make resistance. The glands may be involved by the extension

of a lymphangeitis, but often infection is transmitted through the lymph-vessels to the glands, producing a lymphadenitis without lymphangeitis.

Varieties. — The varieties of *lymphadenitis* are *acute* and *chronic*. The *acute form* is often seen as a result of infected wounds of the extremities, or of chancroid, gonorrhœa, or bubonic plague.

Symptoms. — The glands affected — for example, the axillary — become enlarged, painful, and tender. Should suppuration take place, it is indicated by a chill or chilly sensation, with increased pain, swelling, and tenderness, and the skin over the affected glands becomes red and œdematous, provided the glands are not too deep. At a later stage, if permitted to go without operation, fluctuation may be detected.

CHRONIC LYMPHADENITIS is occasionally a sequel of the acute form, but it is usually caused by the active agent of tuberculosis or syphilis. The glands most frequently affected are those of the neck, the axilla, the groin, the mesentery, and the mediastinum, in all cases being those glands which receive the lymph-vessels which drain the infected area. The inflammation is often chronic from the beginning, and is characterized by the proliferation of numerous round cells with the formation of embryonic tissue, then a low grade of connective tissue, which destroys the normal structure of the gland, resulting in a fibrous, fatty, cheesy, or calcareous degeneration and frequently the formation of pus.

Symptoms.—The disease is seen most frequently in those suffering from poor health from any cause, as exposure, lack of good hygienic conditions, and tuberculous diathesis. The onset is slow, beginning with a progressive *enlargement* of one or more of the glands in the neck,—the part most frequently affected, probably because of the avenues of entrance afforded by the mouth, nose, and ear to pathogenic organisms. There is usually no pain, and for several months or even years there may be little change in the affected glands. Sooner or later, however, other glands become involved, and a chain may be formed extending from the ear or angle of the jaw to the clavicle in front or behind the sternocleidomastoid muscle. *Suppuration* may result from the action of the tubercle bacillus alone or from one of the obligate pyogenic organisms. Suppuration may be limited to a single gland; more frequently it extends to those adjoining and forms a lobulated mass, or it may extend outside of the gland tissue, forming a periadenitis. If left alone the abscess gradually approaches the surface, there is fluctuation, the skin becomes red and finally sloughs, and the discharge of pus follows. The discharge keeps up for a long time, and finally heals with well-

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CHAPTER II.

SURGERY OF THE OSSEOUS SYSTEM.

Diseases of Bone.

SURGERY OF THE OSSEOUS SYSTEM includes diseases and injuries of the bones. Bones, like soft tissues, are liable to wounds, inflammation, infection, tumors, and specific diseases.

INFLAMMATION OF BONE is quite common and may be acute or chronic; and may end in resolution or in destruction, with or without suppuration. Suppuration may be caused by any of the pyogenic organisms, obligate or facultative. The obligate organisms produce the highest grade of inflammation, the infection of syphilis the lowest, inflammation caused by the tubercle bacillus being intermediate. The last two are usually chronic in character. The inflammatory process always originates in the vascular structure of the bone,—the periosteum or medulla—usually the latter,—and as a rule all parts of the bone are involved to a greater or less degree, so that it is proper to use the term osteomyelitis in connection with inflammation of bones.

OSTEOMYELITIS.

ETIOLOGY.—The causes of osteomyelitis may be divided into *predisposing* and *exciting*. *Predisposing* causes are cold or heat in excess, as getting chilled after being overheated from exercise; certain diseases, as typhoid fever, smallpox, malarial fever, pneumonia, syphilis, and tuberculosis; injuries, slight or severe, as contusions, fractures, dislocations, and amputations; suppurating foci in other parts of the body. *Exciting causes* are infection with pyogenic organisms, usually the staphylococcus, streptococcus, tubercle bacillus, or syphilitic material. The fumes of phosphorus produce in those who work with it a form of osteomyelitis of the jaw-bones with necrosis.

PATHOLOGY.—In the *simple*, mild form, the periosteum is thickened and reddened by the proliferation of its cells and the dilatation of the blood-vessels; the lining membrane of the medullary cavity and the contiguous bone are also more or less affected, and caries of the latter may be caused by interference with the circulation in the periosteum. In the *severe* forms of inflammation, embryonic tissue is formed in the medullary and Haversian canals, and by its pressure, or erosion, causes absorption of the bone-substance with enlargement

Treatment.—Rest and elevation of the part and the use of a rubber bandage are sometimes followed by improvement. Ligation of the main artery of the limb has been practised at times with benefit; at other times it has been a failure. As a last resort amputation may be done. When the hypertrophied tissues form lobulated masses they may be excised. The great danger of the operation is hemorrhage, which may to a great extent be prevented by the use of the elastic bandage and by the ligation of all vessels as soon as cut.

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of the medullary and Haversian canals and cancellous spaces, granulation tissue filling the spaces thus made. The process of erosion produces semilunar depressions on the surface of the bone, known as "Howship's lacunæ," which contain "osteoclasts"—giant cells with the faculty of producing absorption of the bone, or *osteoporosis*. The *acute suppurative variety*, if limited, recovers after the evacuation of pus, sometimes with thickening, sometimes with loss, of bone substance. If the inflammation is *diffuse* or of a high grade, unless promptly arrested necrosis with extensive destruction of bone takes place and *sequestra* are formed. Sequestra are fragments of dead bone occurring in the course of the inflammatory process. They may be *superficial*, when occurring on the surface of the bone; *central*, when occurring in the interior; *tubular* or *ring-shaped*, when the entire circumference is involved; or *complete*, when the whole shaft of the bone is included; and vary in size from a fraction of an inch to the entire length of the shaft. Sequestra are white in color, except when exposed to the air, when they turn dark. When felt by

FIG. 106.—Necrosis of humerus.

a probe introduced through the soft tissues, they give a hard, rough sensation different from healthy bone. The envelope of new bone which forms around the sequestrum and more or less completely shuts it in is called the *involucrum*, and the openings in the involucrum through which the sequestrum may be seen or felt are called *cloacæ*. In the process of repair the bone may become thickened from the formation of new bone encroaching on the Haversian canals and cancellous spaces, producing increased density—*osteosclerosis* or *eburnation*. *Tuberculous* osteomyelitis usually results in absorption or softening and gradual disintegration of the bone. The *syphilitic* form is very apt to produce osteosclerosis, but is sometimes followed by absorption or disintegration. The *simple* variety usually terminates in resolution, sometimes in permanent thickening.

VARIETIES.—(1) Simple osteomyelitis, (2) acute diffused suppurative osteomyelitis, (3) chronic diffused osteomyelitis, and (4) chronic circumscribed osteomyelitis.

SIMPLE OSTEOMYELITIS.—*Synonyms.*—*Osteoperiostitis* and *osteitis.*

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SIMPLE OSTEOMYELITIS.—*Synonyms.*—*Osteoperiostitis* and *osteitis.*

Etiology.—This is the mildest variety of bone inflammation, and is the result of a slight injury, without infection or with infection by only a small number of pyogenic organisms.

Symptoms.—Pain, tenderness on pressure, swelling, and œdema, which soon subside under treatment. Should suppuration take place, the patient may have a chill or rigor with elevation of temperature, the swelling is greater, the skin over the affected part becomes red, and fluctuation occurs.

Treatment.—Usually rest and the application of cold or heat as may be most agreeable to the patient are all that is necessary. Suppuration requires early incisions down to the bone, disinfection, and efficient drainage.

Acute Diffused Suppurative Osteomyelitis.—*Synonyms.*—*Acute infectious osteomyelitis, septic osteomyelitis,* and *acute epiphysitis.*

Etiology and Pathology.—This disease may occur in adults in the shaft of a bone as a result of wounds, amputations, etc., but it is more common in children, attacking the ends of the bones near the epiphyseal line, apparently without any connection with wounds. "In most cases it is caused by infection with pus microbes which have found their way into the circulation from a suppurating wound or through the intestinal or respiratory mucous membrane, and which localize in the medullary tissue prepared for their reception by anatomical peculiarities of the capillary vessels or by a *locus minoris resistentiæ* created by injury or some antecedent pathological condition" (Senn). According to Neumann, the capillaries of the medulla are four times as large as the arterial branches which supply them, thus tending to cause congestion. At the diaphyso-epiphyseal junction, in children, the process of growth is rapid and the capillaries are also large and imperfectly developed, furnishing suitable conditions for the location and propagation of bacteria. The occurrence of any of the acute febrile diseases—smallpox, typhoid fever, scarlet fever, or measles—predisposes to the disease, even if they do not furnish the infectious agent. Boys are three times more liable to be affected than girls and probably 50 per cent. of the patients are under eighteen years of age. The organism most frequently found is the staphylococcus pyogenes aureus, sometimes the streptococcus. The bones affected are usually the femur, tibia, humerus, fibula, and radius, and the point of least resistance may be the result of a contusion, sprain, or fracture, a fact which has not only been observed clinically but has also been established by numerous experiments on the lower animals. A sudden chill after being overheated is a predisposing cause.

Symptoms.—Often there is a history of a *chill* coming on a day or two after the patient has suddenly cooled off subsequent to being

overheated. The chill or rigor is followed by *fever* ranging from 102° to 104° F., with rapid pulse, 110 to 120. Sometimes there are symptoms of intense septic intoxication, especially in acute multiple osteomyelitis, the condition closely resembling typhoid fever or acute septicæmia, with unconsciousness, delirium, diarrhœa, rapid pulse, high fever, and death may result within a week or ten days. Besides the chill and fever there is *pain*—one of the earliest and most constant symptoms. It is often excruciating, of a gnawing, boring, or throbbing character, commonly located near the end of one of the long bones, but it may extend to the shaft or to the nearest joint. It is apt to be worse at night, and its sudden cessation means perforation of the bone and the escape of pus into the surrounding tissues. Pain may be absent in *multiple osteomyelitis* or in cases of intense septic intoxication. *Tenderness* is most acute where the disease has approached nearest to the surface of the bone, and is probably caused by a secondary periostitis, but it may be detected in the early stages by careful palpation. This point is usually near the epiphysis. *Œdema* due to obstruction of the veins by thrombophlebitis may be detected in a few days. *External swelling* seldom occurs before the end of the first week, and is due to perforation of the bone and periosteum and the escape of pus into the surrounding tissues, where extensive burrowing among the muscles may take place. *Redness* of the skin appears as the pus approaches the surface. *Synovitis* usually occurs when the inflammation is seated at the epiphysis, and may be *serous* or *purulent* in character. The *serous* form is caused by vascular obstruction, and appears suddenly with pain and swelling of the joint. It often disappears spontaneously. The *suppurative* form is due to infection with the pyogenic organisms which cause the disease or those derived from some external source. *Epiphyseolysis*, a pathological separation of the epiphysis, not infrequently occurs from the fourth to the sixth week. It is caused by necrosis or disintegration of the bone at the epiphyseal line. The condition is indicated by displacement and the detection of a false point of motion. *Loss of function* is complete, the patient being unable to move the limb or to use the joint. After the evacuation of pus the temperature and pulse gradually subside to normal, or, if sequestra are left, evening exacerbations occur.

Diagnosis.—From *typhoid fever* the disease may be distinguished by its sudden onset, continued high temperature, and the severity of the symptoms, and by the absence of the Widal reaction. From *rheumatic fever*, by the point of greatest tenderness being not *in* the joint but at the epiphyseal junction, and, further, by the fact that only one bone is affected. Swelling in the joints does not occur so early in

osteomyelitis. From *phlegmonous inflammation* of the soft parts, by the absence of early swelling and fluctuation.

Prognosis.—This depends on the variety of the disease, the number of bones attacked, the intensity of the inflammation, and the treatment adopted. *Acute multiple osteomyelitis* usually proves fatal in from one to seven days. Fat embolism and metastatic abscesses from infected emboli may be complications. Ankylosis may result from destruction or inflammation of the joint. Of ninety cases treated by German surgeons, according to Senn, the mortality was about 25 per cent.

Treatment.—At the earliest possible moment open the bone at the seat of inflammation, which is indicated by the point of greatest tenderness. Often pus will be seen on opening the periosteum; whether it is or not, open the bone by means of chisel or gouge, until the medullary cavity is exposed. Remove infected marrow with the curette, and if the entire bone is involved make several large openings at intervals, or one long opening over the diseased area in the shape of a trough or gutter, and scrape out the entire medullary cavity, irrigate with 1 to 1000 solution of bichloride, and fill with iodoform gauze. The soft parts may then be united by sutures, leaving sufficient room for drainage. Place the limb in a plaster-of-Paris or other suitable splint, arranged so that access can be had for purposes of dressing. Early operation shortens the disease and prevents necrosis, and is followed by recovery without great delay; but sometimes the inflammatory process continues, necrosis takes place, and *sequestra* are formed, which become detached at variable times, from a few weeks to several months. The treatment of sequestra depends on the conditions present and the size of the sequestra. *Sequestra* when small should be removed, chiselling away the involucrum sufficiently to permit extraction. If the sequestrum involve the entire shaft of a bone, it should not be removed until the involucrum is strong enough to sustain the rigidity of the limb, lest great deformity take place. Bier turns aside a flap containing bone and soft tissues, removes the diseased portion, then returns the flap to its place, and secures it with sutures. To hasten repair Senn

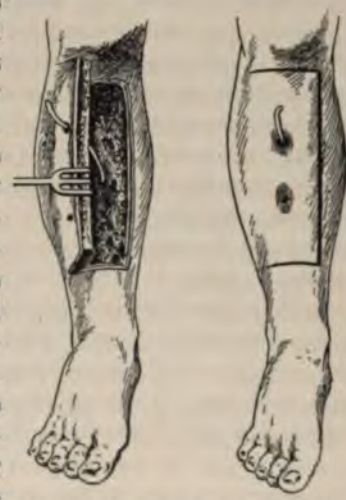

FIG. 107.—Osteoplastic resection for the removal of sequestrum. (Bier.)

recommends the filling of the cavity with decalcified bone chips, and Schede allows the cavity to fill with blood-clot, which becomes organized. Where a considerable portion of the length of a bone has been removed, leaving a gutter-like depression, it may be filled by turning the soft tissues into it and retaining them in that position by sutures or compresses. Amputation may become necessary in prolonged suppuration, especially if the joints are involved.

CHRONIC DIFFUSED OSTEOMYELITIS.—*Synonyms.—Tuberculous* or *syphilitic osteomyelitis.* Chronic osteomyelitis may be the result of the acute form, but it is usually subacute or chronic from the beginning. It may be caused by the obligate pyogenic organisms, but is more frequently the result of infection by the tubercle bacillus or the poison of syphilis. The bones usually affected are the vertebræ, the femur, the humerus, and the carpus. The head of the humerus and the carpus are most frequently affected in adults.

Pathology.—(See chapters on TUBERCULOSIS and SYPHILIS.)

Symptoms.—In the early stages of the disease the symptoms are often obscure. *Pain* is nearly always present, but varies in degree, and is seldom as severe as in acute osteomyelitis. It is intermittent and worse at night. *Tenderness* on pressure is usually detected. Sometimes there is no pain, but the patient may complain of being easily tired. *Rigidity* and *spasm* of the muscles are among the most reliable symptoms, and usually exist whether pain is present or not. Later *atrophy* of the muscles from inaction or from trophoneurotic lesions takes place. *Swelling* is absent until destruction of the bone and periosteum has released the pus, when it follows the lines of least resistance, and may open into cavities or reach the surface of the body some distance from its point of origin. *Redness* of the skin does not occur until the pus or granulations have reached the skin and it is about to slough. The general temperature is usually not elevated above the normal, but it may be slightly increased locally over the affected region.

Diagnosis.—From *acute* osteomyelitis it is distinguished by the absence of fever and of acute symptoms, though fever may appear after suppuration occurs; from *synovial* tuberculosis, by the tenderness first appearing in the epiphyseal region, not in the joint, and by the absence of joint-swelling in the early stages of the disease. At a later period it may be impossible to make the distinction. Most cases of tuberculous osteomyelitis occur in children.

Prognosis.—This is more favorable in children and young adults. Recovery may take place spontaneously, or as a result of treatment under favorable conditions; but if great destruction of bone takes place, with exhaustive suppuration, the patient may die from sep-

ticæmia or from amyloid degeneration of the viscera. A colony of bacilli may be imprisoned as a result of osteosclerosis, and remain inactive for years, when they may be liberated and produce a reinfection or general dissemination. Volkmann has summed up the history of such a case as follows: Tuberculosis of the lymphatics, in childhood; of the bones, at puberty; and death before thirty, from general dissemination.

Treatment.—Secure rest of the part by keeping the patient in bed or by the use of plaster-of-Paris or other splints which may be adjusted so as to preserve immobility of the diseased bone and yet permit the patient to take exercise in the open air. Ignipuncture, by introducing the point of a thermocautery into the diseased focus; or injections of pure carbolic acid, of chloride of zinc, 2 per cent., of balsam Peru, or of iodoform 10 per cent.; are used to destroy the bacilli or inhibit their growth. The cautery is best in the early stages of the disease, and iodoform emulsion after the formation of abscesses. If the patient fail to improve under treatment by rest and apparatus, excision of the infected focus may be practised. The bone should be exposed and opened by means of a chisel or gouge, taking care not to open the adjacent joint. The diseased tissue should be thoroughly removed by the curette, disinfected with bichloride solution or pure carbolic acid, and packed with iodoform gauze.

Chronic Circumscribed Osteomyelitis, or Bone Abscess.—This is a circumscribed inflammation, usually affecting the cancellous tissue, but also occurring in the medullary cavities of the long bones, generally the lower end of the femur and upper end of the tibia; sometimes the lower end of the tibia and upper end of the humerus. It may follow an attack of acute osteomyelitis in a short time or after the lapse of years. The infectious agent may be the same as that of acute osteomyelitis, but it is usually the tubercle bacillus. A slow inflammation takes place which results in osteosclerosis and the formation of a dense bony wall in which the abscess is confined. It is as if an enemy, too strong to be destroyed, were besieged in a city. Should the inflammation become severe, the garrison reinforced, or the besiegers from any cause weakened, the enemy bursts through his confines and a general invasion of the territory takes place.

Symptoms.—The constitutional symptoms are seldom well marked. There may be slight *fever*, the *pain* is dull, boring, deep-seated, worse at night, and there is apt to be *tenderness* over the affected region and slight *swelling* or *enlargement* of the bone may be detected. *Œdema* is occasionally present. In some cases of chronic osteo-

myelitis, instead of an abscess forming there may be an overgrowth of bone and an increase in its length; for example, a femur may be an inch longer than its fellow; on the other hand, the bone may be shorter from arrest of development due to the inflammatory process.

The *diagnosis* must be made from syphilitic disease and from sarcoma. If this cannot be done by the history and symptoms, an exploratory incision and puncture of the bone must be made.

Treatment.—A careful examination by palpation should be made and the bone exposed by incision over the most sensitive point. A drill may then be used to make exploratory punctures, over a considerable area if necessary, until pus is found. The cavity should be freely opened by the chisel or gouge, the pus evacuated, or the diseased tissue removed by the curette, disinfected with carbolic acid, and packed with iodoform gauze.

OSTEOMALACIA.

Synonyms.—Mollities ossium and *malacosteon.* This is a disease of nutrition, observed chiefly in adults, 91 per cent. of the cases occurring in women, especially during pregnancy or lactation or in those who have borne many children. It is characterized by progressive softening and subsequent deformity of various parts of the skeleton. The *cause* of the malady is unknown, but it has been attributed to disease of the trophic nerves, excess of lactic acid, ovarian and uterine disorders, and imperfect nutrition.

Pathology.—On examining the affected bones the *periosteum* is found to be thicker and more vascular than normal, the *medulla* degenerated and replaced by round cells or embryonic tissue, the bony *trabeculæ* absorbed or destroyed, leaving small cavities, and a general deficiency in lime salts, or decalcification, exists. It differs from rickets because in *rickets* the lime salts have not been deposited in the bones, while in osteomalacia the salts have been deposited but they are afterwards removed and eliminated by the kidneys.

Symptoms.—The *premonitory* symptoms are failure of the general *health*, with vague, wandering rheumatoid *pains*, and the urine contains an excessive amount of phosphate and carbonate of calcium. Later, deformity from bending of the bones takes place, the bones of the pelvis being first affected in pregnant and nursing women and other bones later, while in non-puerperal women and in men the bones of the spine and chest are affected. Multiple fractures may occur.

Diagnosis.—The diagnosis is made from *rheumatic fever* by the absence of fever or affection of the joints; from *tumors* of bones by the number of bones affected.

Prognosis.—The disease progresses slowly, but the prognosis is unfavorable and a fatal result is the rule. In pregnant and nursing women recovery sometimes takes place after delivery or the cessation of lactation. Other cases are slowly fatal from exhaustion or disease of the lungs. Fractures have no tendency to heal, nor deformities to remain corrected.

Treatment.—Give phosphoric acid, the salts of lime, and cod-liver oil. Lactation should be stopped and the induction of premature delivery is justifiable. Ovariotomy in non-puerperal cases has been employed, apparently with good results.

FRAGILITAS OSSIUM.

This is a disease of nutrition characterized by abnormal *brittleness* of the bones, owing to diminution of the organic elements. It is usually seen in children and young persons.

Etiology.—It is supposed to be due to imperfect innervation or to trophic disturbances, *heredity*, *general paralysis* of the *insane*, *syphilis*, *locomotor ataxia*, *malignant tumors*, the early stage of *rickets*, or long *confinement* after injury to bones or joints. It is sometimes seen in persons who are otherwise apparently healthy.

The *symptoms* are repeated fractures from trivial causes, frequently repeated and affecting numerous bones. The fractures readily unite when properly treated, and refracture with equal facility.

Treatment.—But little can be done except to treat the fractures in the usual way. Sometimes as the patient reaches maturity recovery takes place.

RICKETS.

Rickets, or *rhachitis*, is a disease of infancy and childhood, characterized by a disturbance of nutrition, with an insufficient deposit of lime salts and irregular development of the bones.

Etiology.—Rickets is a disease of bad hygiene and is usually seen among the poor in large cities who live in crowded houses and have insufficient food. Children artificially fed are more liable to the disease. It usually develops from the sixth month to the end of the second year, but may occur in fetal life or as late as the fifth or sixth year after birth—occasionally in adults. The disease is frequently seen in animals kept in menageries under highly artificial conditions (Warren).

Pathology.—There seems to be a *deficiency* in the supply of the lime salts or a defect in their assimilation. The *periosteum* is thick and vascular and the *bone* beneath is red, soft, and spongy, and can be readily cut with a knife, especially at the epiphyseal lines of the long

bones, where the cartilage fails to become ossified, forming "osteoid tissue." The line of calcification is absent. The zone of cartilage cells is greater than normal and irregular, vascular, medullary spaces grow up into the cartilage in tortuous shapes. What ossification takes place is irregular, so that patches of cartilage are found far below the upper edge of the bony tissue. The ends of the bones are much thickened.

Symptoms.—The earliest symptoms, in young children, are *restlessness* at night, profuse *perspiration* of the head, *constipation*, *swelling* of the abdomen, and an excessive amount of phosphates in the urine. In older children, perhaps backwardness in learning to *walk* or *sit upright*; *large fontanelles*, slow in closing; imperfectly united sutures; craniotabes (skull very thick and very thin in places); head increased in size transversely, with bulging forehead; sometimes hydrocephalus or sclerosis of the brain; delayed dentition and irregular eruption of the teeth. The epiphyses are enlarged, especially the lower end of the radius and the junction of the costal cartilages with the ribs on either side, giving the double row of protuberances called the "rhachitic rosary." The *ribs* are flattened, allowing the sternum to project in front—"pigeon-breast." Spinal curvatures, contracted pelvis, bowlegs, knock-knee, and loose joints may result. The *mental faculties* do not seem to be affected and the patients are often precocious. The disease is slow in progress and may extend over one or two years.

The *prognosis* is good. When death takes place it is from some complication of the weakened condition of the patient. Deformities are often spontaneously corrected; occasionally they persist through life.

Treatment.—Provide good hygiene, change of climate, and salt-water baths; the child should be nursed by the mother, but if a bottle is used the milk should be fresh and carefully prepared. Cod-liver oil may be used internally or by inunction. The best drugs are iodide of iron, small doses of phosphorus, the hypophosphites, the lactophosphate of lime, and the tincture of eucalyptus globulus. Deformities should be corrected, or prevented by the use of splints.

ACROMEGALY.

ACROMEGALY (enlargement of the apex) is a peculiar disease, first described in 1885 by Marie, characterized by a progressive symmetrical enlargement, a true hypertrophy of the bones and soft tissues of the lower jaw, thorax, vertebræ, pelvis, and extremities. It is more frequently seen in women between the ages of fifteen and thirty-five, and has been variously attributed to hereditary syphilis,

specific fevers, sclerosis of the lower cervical ganglia, and diseases of the pituitary body and thymus gland. The thyroid gland is sometimes atrophied.

Symptoms.—Persistent *headache; mental hebetude*, often approaching imbecility; *wasting* of the *muscles;* exaggeration or loss of *reflexes; general weakness;* great increase in size and weight of the *lower jaw*, the *supraorbital ridges*, the *ribs*, the scapulæ, and the *vertebræ* and *intervertebral disks*. *Kyphosis* often occurs. The extremities become affected later, the legs, forearms, feet, and hands being sometimes increased to enormous proportions. The disease is slow in progress, but the patients have slight resisting power and usually die young, of consumption or some other infectious disease.

The *treatment* is experimental. Thyroid extract has been recommended.

Injuries of Bone.

FRACTURES.

General Considerations.—A *fracture* (from *frango*, I break) may be defined as the sudden destruction of the continuity of bone or cartilage produced by violence. This includes epiphyseal separations and the separation of ribs from their cartilages. Fractures are said to constitute one-seventh of all injuries (Bruns). They are about three times as frequent in males as in females, but the proportion differs according to age. In infants and between the ages of fifty and seventy years both sexes are about equally affected. After seventy women are more frequently affected, the most common fracture being that of the neck of the femur. During middle life fractures are ten times more common in men than in women. In proportion to the number of persons living at any one age, fractures are most frequent about the age of sixty years. By reference to Gurlt's table of about 52,000 fractures, it will be seen that fractures of the upper extremity are twice as numerous as those of the lower extremity, three times as numerous as those of the trunk, and about thirteen times as numerous as those of the head. The clavicle is the bone most frequently fractured—some statistics give the radius. Fractures are about ten times as frequent as dislocations.

GURLT'S TABLE.

Fractures treated in London Hospital, 1848–1877.

	Hospital.	Out-Patients.	Total.	Per cent.	Number by Regions.	Per cent.
Skull	730	27	757	1.457	Head, 2,002	3.854
Face	732	513	1,245	2.397		
Spine	169	3	172	0.331	Trunk, 9,067	17.457
Pelvis	139	3	142	0.273		
Coccyx	5	10	15	0.028		
Ribs	4,784	3,477	8,261	15.905		
Sternum	45	7	52	0.100		
Scapula	135	290	425	0.818		
Clavicle	382	7,458	7,840	15.094	Upper extremity, 27,119	52.214
Arm	1,064	3,020	4,084	7.863		
Forearm	709	8,731	9,440	18.175		
Hand	856	4,899	5,755	11.080		
Thigh	3,072	171	3,243	6.243	Lower extremity, 13,750	26.473
Patella	649	15	664	1.278		
Leg	8,067	256	8,323	16.024		
Foot	965	555	1,520	2.926		
Totals	22,503	29,435	51,938			

STIMSON'S TABLE.

Hudson Street Hospital, New York. Statistics of Fractures treated in Hospital and Dispensary, 1894–1897.

	Cases.		Cases.	Per cent.
Cranium	262	Head	262	5.77
Malar bone	6	Face	371	8.17
Nasal bones	234			
Superior maxilla	14			
Inferior maxilla	109			
Zygoma	8			
Spine	23	Trunk	524	11.55
Pelvis	14			
Coccyx	3			
Sternum	2			
Ribs	482			
"Upper extremity"	132	Upper extremity	2,364	52.08
Clavicle	200			
Scapula	16			
Humerus, shaft and neck	103			
internal condyle	32			
external condyle	24			
internal epicondyle	1			
Radius and ulna	73			
Radius, shaft	128			
Colles's	352			
Ulna, shaft	97			
olecranon	26			
Carpus	3			
Metacarpus	304			
Phalanges	873			

	Cases.		Cases.	Per cent.
Femur	154			
Patella	49			
Tibia, or tibia and fibula	281			
Abduction and adduction fractures at ankle	292			
Fibula	43	Lower extremity	1,018	22.40
External malleolus	9			
Internal malleolus	4			
Tarsus	26			
Metatarsus	90			
Toes	70			
Total	4,539			

During the same period 421 dislocations were treated.

VARIETIES.—All varieties of fracture are classed under *simple* or *closed* and *compound* or *open*.

A *simple or closed fracture* is one in which there is no communication with the air.

A *compound or open fracture* is one which communicates with the air, through a wound in the skin or mucous membrane.

Fractures are further divided into: Complete, incomplete, multiple, gunshot, complicated, comminuted, impacted, spontaneous, pathological, and ununited.

A *complete fracture* is one which passes through the entire thickness of the bone.

Subdivisions are: (*a*) *Transverse*, when the line of fracture passes more or less at right angles to the long axis of the bone; *longitudinal*, when it runs almost or quite parallel with the long axis of the bone; *oblique*, when it runs in a direction between transverse and longitudinal; *spiral*, when it has a tendency to encircle the bone obliquely, usually caused by torsion; *toothed*, *dentated*, or *serrated*, when projections and depressions are formed; *V-shaped*, when a triangular projection is formed which fits into a corresponding depression in the shape of a V; *T- or Y-shaped*, seen in the lower end of the humerus and femur in which a transverse fracture passes above the condyles, joined by a longitudinal one running between the condyles into the joint. (*b*) According to the seat of fracture, as it occurs in the neck, condyle, shaft, body, or

FIG. 108.—Transverse fracture.

FIG. 109.—Oblique fracture.

process of a bone. (*c*) According to the relation with *joints*, into *intra-* and *extra-*capsular.

An *incomplete fracture* is one in which the line of fracture does not involve the entire thickness of the bone. This includes: (*a*) *Fissures*, which are splits or cracks, especially of the skull. (*b*) *Greenstick fracture*—seen in the long bones, in young persons. It consists in a giving way of part of the thickness of a bone with some longitudinal splitting, while the remaining fibres bend instead of breaking, just as a green stick partly breaks when forcibly bent across the knee. (*c*) *Depression*, in which a portion of the thickness of a bone is depressed by crushing, as in the skull when the outer table is depressed into the diploe without affecting the internal table.

FIG. 110.—Incomplete or "greenstick" fracture of the radius.

FIG. 111.—Comminuted fracture.

FIG. 112.—Impacted fracture of the neck of the femur. (After Miller.)

A *multiple fracture* is one in which there are two or more fractures of a single bone, the lines of fracture not communicating; or the fracture of two or more separate bones which do not occupy the same segment of the limb.

The term *double* may be applied to fracture of corresponding bones on the two sides of the body; for example, fracture of both radii.

Gunshot fractures are of especial importance on account of the extensive injury to the bone, which is often out of proportion to the small size of the missile.

A *complicated fracture* is one attended with serious injury to adjacent structures.

A *comminuted fracture* is one in which the bone is broken into numerous fragments, the lines of fracture communicating with one another.

An *impacted fracture* is one in which one fragment is driven into and fixed in the other.

FIG. 113.—Skiagram of V-shaped fracture of tibia.

FIG. 114.—Skiagram of gunshot wound of the humerus.

Fig. 115.—Epiphyseal separation of lower end of the humerus.

A *spontaneous fracture* is one produced by very slight violence.

A *pathological fracture* is one produced by trivial force, as the result of disease which weakens or destroys the bone.

An *ununited fracture* is one in which union has failed to take place after something more than the usual lapse of time.

Epiphyseal separation is the separation of an epiphysis from its diaphysis at the cartilaginous junction. It is seen in persons under twenty years of age before the cartilaginous union has become ossified, and occurs most frequently in the lower ends of the femur and radius and the upper end of the humerus. It is apt to interfere with the future growth of the bone in length.

ETIOLOGY.—The causes of fracture may be divided into *predisposing* and *exciting*.

The *predisposing causes* are: *Sex*,—10 to 1 against men during active life. *Changes in the structure of the bones*, from age or certain diseases, as rickets, syphilis, cancer, and disease of the nerve centres. *Age:* In old age the bones become more fragile from atrophy. *Shape and position in the skeleton:* The long bones are more liable to fracture than the short or irregular bones, because of their length, use, and exposure.

Exciting causes are: *External violence* and *muscular action*. External violence may be direct or indirect. In a fracture by *direct* violence the bone is broken at the point where the violence is applied. In fractures by *indirect* violence the fracture occurs at a point distant from the application of the violence, as where the force is applied to the two ends of a long bone, causing fracture at the weakest point. *Muscular action*, by sudden, strong contraction, will sometimes cause fracture.

SYMPTOMS and SIGNS of fracture are divided into *subjective* and *objective*.

Subjective Symptoms.—Pain, spontaneous or caused by pressure or motion, is a constant symptom. *Loss of function*, more or less complete, according to the nature of the fracture and the bone affected. *Shock*, or other constitutional disturbance, as chill or rise of temperature, sometimes seen after fractures of large bones, like the femur.

Objective Symptoms or Signs.—Deformity, which may be: Swelling, from injury to the soft parts (ecchymosis, with a mottled appearance of the skin, occurring a day or two after the injury, indicates, according to Dennis, that the source of the blood is the medullary cavity); *transverse* or *lateral displacement*, where one fragment moves to the side, front, or back of the other, but not sufficiently to overlap it; *angular*, in which the long axes of the two fragments make an angle with one another; *rotary*, in which one fragment rotates on its long

axis, the other perhaps remaining stationary; *shortening* or *overriding*—one fragment overlaps the other, producing shortening; *longitudinal separation*, as in fracture of the patella, olecranon, and os calcis; and *impaction*, in which one fragment penetrates and remains fixed in the other, indicated by more or less shortening.

The *existence of an abnormal point of motion*, when clearly established, is pathognomonic of fracture. This is absent in impacted fractures.

Crepitus is a sign of great value, and is both a sensation and a sound. It is obtained by rubbing the two fragments together. Care should be taken in attempting to elicit this sign not to injure the soft parts or to break up an impaction inadvertently. Conditions which may be mistaken for crepitus are *crackling*, from the presence of gas in the tissues; the *grating* of *osteophytes*, or of *tendinous sheaths* from inflammatory deposits. From these crepitus is to be distinguished by attending conditions rather than by the difference in the character of the sound or sensation.

Circumstantial signs of fracture are such as the flow of blood and cerebrospinal fluid from the ear in fracture of the middle fossa of the skull, etc.

Diagnosis.—There is no difficulty in making the diagnosis of fracture if displacement, mobility, and crepitus are present. When great swelling has taken place, or in impacted fractures or those situated near a joint, the diagnosis may be difficult. Impacted fractures may be detected by considering the history of the case, seat of the pain, and noticing carefully any deformity, such as a slight degree of shortening. Fractures may be distinguished from *dislocations* by the existence of an abnormal point of motion, and, possibly, shortening and crepitus. In dislocation the *shaft* of the bone is not shortened and there is no abnormal point of motion in the bone. *Epiphyseal separation* may be recognized by the age of the patient (under twenty); the situation; the absence of crepitus, or, if present, of the soft variety; and the use of the Roentgen ray.

Prognosis.—The prognosis depends on the age, sex, and general condition of the patient, as well as on the character of the fracture and the treatment employed. Compound, especially gunshot, fractures are more serious than other varieties, and often require two or three times as long to repair.

Repair of Fractures.—On the occurrence of a fracture the soft tissues, including the periosteum, are more or less injured. This is followed by the effusion of blood and the formation of a clot. The periosteum is torn, but fragments usually remain connecting the ends of the bone (periosteal bridges), which are supposed to play an im-

portant part in determining the location of new bone in the process of repair. There are an accumulation of leucocytes and a proliferation of the cells of the periosteum, the medulla, and other tissues by karyokinesis. This accumulation of cells of various sizes and shapes forms a mass of embryonic tissue which fills up the medullary cavity, lies between the ends of the bones, and forms a spindle-shaped mass which surrounds the two fragments. This is the *temporary* or *provisional* callus. The portion on the outside, formed principally by the periosteum, is known as the *external* callus; that in the medullary cavity, the *internal* or pin callus; and the portion between the ends of the bones, the *intermediary* callus. Ossification takes place by means of *osteoblasts*, and the callus is gradually converted

FIG. 116.—Formation of callus in a fracture seven days old: *a*, proliferating periosteum fibroblasts with mitoses; *b*, newly formed cartilage; *c*, small blood-vessel with swollen endothelium; *d*, granulation-tissue; *e*, a layer of bone which takes no part in the process. (F. C. Wood, M.D.)

into spongy bone. *Osteoblasts* are large angular cells which make their appearance about the third or fourth day after the injury, lying in the deep layers of the periosteum and in the membrane lining the medullary cavity. Their function is to deposit lime salts in the embryonic or osteoid tissue, usually beginning about the third week. Blood-vessels extend into the callus while it is soft, the osteoblasts arrange themselves around them in concentric rings and form successive layers of bone from without in. Thus the *lamellæ* and the Haversian canals are formed. Some of the osteoblasts are left between the rings of bone, forming "bone-corpuscles" lying in the lacunæ. The manner in which the canaliculi are formed is not known. In the mean time the ends of the bone undergo an osteoporosis, the Haversian canals being filled with round cells gradually enlarge so that the bone becomes porous, soft, and finally the granulation tissue on the two

ends meets, blends, and becomes ossified. This is the *definitive* or *permanent* callus, and is completely ossified in about four months. The *provisional* callus holds the fragments firmly in place while the *permanent* callus is being formed, after which, there being no further use for it, a process of absorption takes place, by means of which the provisional callus disappears from the medullary canal and from the outside of the bone. This is supposed to be done by the *osteoclasts*, large, angular cells lying in semilunar excavations—lacunæ of Howship—in the bone substance, beneath the periosteum, or in the medullary spaces. According to Senn, they are simply *osteoblasts* which have lost their bone-producing function, and absorption follows from want of supply. Klebs believes that they secrete a chemical substance which decalcifies bone. Both the temporary and permanent callus are at one time porous, but, while the temporary callus becomes more and more porous until it is completely absorbed, the permanent callus becomes more compact and harder until it has the composition of true bone. Sometimes the callus fails to ossify, and *delayed union* or *ununited fracture* results. In other cases no callus is formed, but a process of absorption takes place so that the ends of the bones are rounded off, pointed, and diminished in size, or completely absorbed (Warren). Exuberant callus may press on surrounding structures, include nerves, or encroach on neighboring joints. Sometimes callus is arrested in its development in the fibrous stage, and fibrous union is the result. In spongy bone the reparative process proceeds more rapidly, and is done principally by the bone itself, as, on account of its porosity, granulation tissue forms sooner than in compact bone. Fractures of cartilage are repaired by fibrous tissue; sometimes the tissue is partly cartilaginous and partly bony (Stimson).

Complications of Fractures.—*Hemorrhage* usually gives no serious trouble. *Surgical emphysema*,—the entrance of air or gas into the connective tissue of a part; the source of the gas may be a wound of the lung, intestine, air sinuses in the bones of the head, or it may result from the growth of gas-producing bacilli, as the bacillus of malignant œdema or the bacillus aerogenes capsulatus. *Fat embolism*, from crushing of the bone marrow, may occur in the lungs, brain, spinal cord, and kidneys.

Other complications are gangrene, septicæmia and pyæmia, osteomyelitis, delirium tremens, pneumonia, tetanus, œdema of limbs, and stiffening of joints and tendons.

General Treatment.—For transportation the limb may be temporarily fixed by the application of splints outside of the clothing of the patient. Splints may be extemporized from wisps of straw, oakum, or several folds of the clothing, as the coat of the

patient or of an attendant, which may be applied and fixed to the limb by means of bandages or strings. Take care, in lifting the patient, to handle the limb properly, lest damage to the soft tissues be produced, or a simple fracture be converted into a compound one. Before lifting, always extend the limb; for example, in fracture of the leg the foot should be grasped by the ankle and strong extension made, when the limb may be lifted with safety and comparative ease to the patient.

At the hospital, the clothing should be removed, as a rule, by ripping up the seams and cutting off the boots or shoes, to avoid unnecessary movements of the limb. Frequently it is necessary to give an anæsthetic, to prevent pain, to relax the muscles, and permit of proper reduction. Should the muscles prevent sufficient extension to bring the ends of the fragments into apposition, Dennis advises tenotomy of any muscles which resist. After adjustment of the fragments, suitable splints are applied, in order to immobilize the parts, including the nearest joints, and prevent a recurrence of the displacement. If there is much *swelling*, with the formation of blebs or great damage to the soft tissues, the limb should be placed in a fracture-box or supported by sand-bags until in a suitable condition for the application of splints.

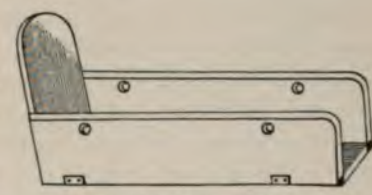

FIG. 117.—Fracture-box.

Three methods are used in the treatment of fractures: (1) *Permanent fixation*, in which the fragments are immobilized until union occurs, removing the apparatus only at rare intervals, for examination or for other good reason. (2) The *ambulatory method*, which consists in the application of a plaster-of-Paris cast, in fractures of the lower extremity, so as to transmit the weight of the body from a point above the fracture to the ground through the cast, thus enabling the patient to walk on the fractured limb during the process of repair. (3) The *method of massage*, advocated by Lucas Championnière. Extension is made by assistants while the surgeon massages the limb fifteen or twenty minutes daily until union takes place. No retentive apparatus is used, unless there is a marked tendency to displacement.

The best method is that by permanent fixation. Good results may be obtained in well-selected cases by the other methods,—the *ambulatory* in transverse fractures of the leg with little or no tendency to displacement; the method by massage in fractures of the upper extremity with like conditions.

Splints are made of wood, metal, pasteboard, felt, leather, plas-

ter of Paris, starch, gum, and silicate of sodium or of potassium. *Wooden splints*, made of light, thin wood, are frequently used. They should be well padded, longer than the broken bone to which they are applied, and wide enough to prevent constriction when the bandage is applied. Two boards are generally used, held in place by means of strips of adhesive plaster or turns of a roller bandage. *Metal splints* may be constructed of tin, sheet-iron, or wire. *Pasteboard*, or *binder's board*, is good material for splints. They can be soaked in hot water and moulded to the limb. Undressed leather and felt may be used. *Plaster of Paris*, or gypsum, is one of the best materials for making fracture dressings. It may be used in the form of a *splint*, or as a complete *encasement* of the limb. The plaster *cast* is made by rubbing dry plaster of Paris into the meshes of gauze bandages as they are rolled up, dipping the rollers into water until they become thoroughly saturated, and applying from two to six layers of bandage to the limb by circular turns. Before applying the bandage protect the skin by means of a smoothly applied flannel bandage or by cotton wadding. After encasement of a limb in plaster, watch the circulation carefully by observing the toes, which are left exposed for that purpose. After hardening, split the cast on each side and retain in place by adhesive plaster or bandages. The posterior half of the cast, used alone, forms the "gutter splint." *No patient should be allowed to leave the hospital, after a primary dressing of this kind, without having had the plaster split as described. Neglect of this precaution has resulted in gangrene and the loss of the limb.*

DELAYED UNION AND UNUNITED FRACTURES.

Delayed union is not uncommon, and may be the result of local or constitutional conditions. If a fracture fail to unite after the usual length of time—six or eight weeks—it is said to be a case of delayed union. If, after the lapse of another period of time,—say, four or five months from the beginning,—there is still no union, it is called a case of *ununited fracture*. This is a rare result. On examining the fragments they are usually found to be partially united by means of fibrous tissue, perhaps ossified in parts, and the ends of the bone may be rounded off or pointed. Sometimes the fibrous tissue uniting the fragments forms a capsule containing a synovia-like fluid about the ends of the bone, which may be smooth and covered with cartilage, making a *pseudarthrosis*.

ETIOLOGY.—The causes of non-union are *anatomical*, *local*, and *constitutional*.

The *anatomical causes* depend on the direction in which the nutrient artery of the bone runs. The end of the bone *opposite* that

towards which the nutrient artery runs is most likely to be the seat of non-union. Assume a sitting posture with the elbows, hips, and knee-joints strongly flexed; the nutrient arteries of the extremities in that position all run down, that is, *away from* the knee-joint, *towards* the ankle and hip, and *away from* the wrist and shoulder and *towards* the elbow. (Dennis.) The bones most frequently affected are the humerus, especially the upper end, the tibia, and the femur.

FIG. 118.—Ununited fracture of the humerus, with pseudarthrosis. Skiagram of opposite cut.

FIG. 119.—Ununited fracture of the humerus after four operations.

Local causes are the intervention of soft tissue; too much mobility; too much space between the fragments, or imperfect coaptation; interference with the circulation from swelling, improper use of bandages, or the pressure of fragments of bone; injury to the nerve; inflammatory processes; or the existence of compound fracture.

Constitutional causes are: *Age*, the condition being most frequent in middle life; and certain *diseases*, as rickets, scurvy, diabetes, febrile conditions, pregnancy, prolonged lactation, and syphilis.

TREATMENT.—If, after a reasonable time, there is no union, the ends of the bone may be rubbed together. Should this fail, or in older cases, *drilling* may be tried, making several drill holes in each end. *Braces* or *splints* may be used to enable the patient to use the

affected limb, and a good result is often obtained, probably from improved circulation or constitutional condition.

FIG. 120.—Brainard's bone-drills.

FIG. 121.—Partial suture of bone. (Wharton and Curtis.)

FIG. 122.—Complete suture of bone. (Wharton and Curtis.)

Excision.—Old cases, and especially those in which *pseudarthrosis* exists, are best treated by excising the fibrous tissue, freshening the

FIG. 123.—Fragments secured with a silver splint and screws. (Wharton and Curtis.)

FIG. 124.—Fragments secured with a screw. (Wharton and Curtis.)

FIG. 125.—Fragments fixed with a bone ferrule. (Wharton and Curtis.)

ends of the bone, and uniting them by means of animal or metallic sutures,—nails, metal plates, ivory pegs, or a bone ferrule. In oblique

fractures the ends may be sawed in such a manner as to permit splicing, when they may be held in place by kangaroo tendon, or coarse catgut wrapped around the bone and tied. In ununited fracture of one bone in a segment of a limb containing two, as the forearm, in which non-union is due to loss of bony substance, it may be necessary to resect a portion of the sound bone, to permit the ends of the fractured one to be brought into apposition.

Constitutional treatment is necessary in syphilis, or any diathesis. Kassowitz recommends minute doses of phosphorus, in order to produce osteoporosis and stimulate the bone-producing processes.

FAULTY UNION (deformity) may result from imperfect reduction, improper dressings, or disobedience of the patient, and if the usefulness of the part be compromised, the treatment consists in refracture or osteotomy and the proper adjustment of the fragments.

COMPOUND FRACTURES.

Compound fractures are serious injuries. They may be produced by direct force and then are more severe than when they result from indirect violence.

In the *treatment* of compound fractures the indications are to *arrest hemorrhage, prevent infection, disinfect the wound*, provide for *efficient drainage*, and *immobilize the fragments*. It has been well said that the fate of a patient's limb, or even life, often depends on the surgeon who first touches the wound. Hemorrhage is arrested in the usual way. Preparation should be made for a thorough antiseptic operation, and as a rule the patient should be anæsthetized, the limb and wound thoroughly cleansed with soap and water applied with a brush, then alcohol and solution of bichloride 1 to 1000. If the wound is very small, as in fractures from indirect violence, the projecting end of the fragment and the surface of the wound should be sponged off with bichloride solution, the fracture reduced, and the wound closed with sutures and sealed with collodion. In severe forms explore the deepest recesses, remove fragments of bone completely detached and all visible dirt, trim devitalized tissues, and wash the entire wound with bichloride solution. Drainage is provided for by a rubber tube or wisp of gauze, the fragments adjusted and fixed by a plaster-of-Paris cast, or, if this is inadvisable on account of swelling or excessive injury to the soft tissues, the limb may be placed in a fracture-box. Should everything go well, as indicated by the pulse, temperature, and local circulation, the dressing need not be disturbed until the third day, when a window should be cut in the plaster over the wound to permit examination and change of dressing.

SPECIAL FRACTURES.

Fractures of the different bones should be studied under the following heads: Frequency, varieties, etiology and pathology, symptoms and signs, differential diagnosis, complications, and treatment.

FRACTURE OF THE NASAL BONES.—Of the bones of the face, the *nasal* bones and the *inferior maxilla* are those most frequently fractured. The most common seat of fracture of the nasal bones is in the lower third, where they are thin. The line of fracture may be transverse or oblique, and may extend to the nasal process of the superior maxilla or to the cribriform plate of the ethmoid bone. Fractures may be comminuted or compound by reason of wounds in the skin or mucous membrane. They are usually caused by direct violence.

Symptoms and Signs.—Pain; swelling; hemorrhage from the nose; deformity, the nose being flattened or deviated laterally; and an abnormal point of motion and crepitus may be detected.

Complications.—Hemorrhage; emphysema of the face and eyelids; septic meningitis, if the cribriform plate be involved; and, rarely, suppuration, necrosis, and obstruction of the lachrymal duct.

Treatment.—Set the fragments and straighten the septum as soon as possible, as repair takes place rapidly. This is done by pressing the fragments into place by means of the fingers, aided if necessary by a dressing forceps wrapped with cotton, used within the nasal cavities. To prevent recurrence of the displacement, apply pads on either side of the nose and keep in place with adhesive plaster; plug the nostrils with gauze packed around a hard-rubber tube; or pass a needle through the nose from one side to the other beneath the fragments, which are held in place by a strip of gauze passing from one end of the needle to the other across the nose. Use lead and opium and evaporating lotions for the swelling. Repair occurs in from three to five weeks.

FRACTURES OF THE MALAR BONE are rare and are usually the result of direct violence or of gunshot wounds. The bone may be driven into the antrum of Highmore or the zygomatic arch may be fractured.

Treatment.—If the malar bone has been driven into the antrum, producing deformity, restore it to its position with a lever or gimlet used through an incision made in the mouth just below or in the cheek just over the bone. A fractured zygoma may be reduced with the fingers. If depressed, it may be pried out through an incision in the skin or by pulling on the ends of a strong ligature passed beneath the bone with a curved needle.

FRACTURES OF THE SUPERIOR MAXILLA, with the exception of the alveolar border, are rare, but the line of fracture may extend through the nasal, orbital, or palate processes or through the body of the bone. The line of fracture sometimes passes through the body of the bone below the articulation with the malar, through the antrum, the body of the palate bones, and the nasal fossæ and pterygoid processes, detaching the entire alveolar arch with the palate processes of both superior maxillæ and palate bones and the pterygoid processes of the sphenoid.

The *cause* is usually direct, occasionally indirect, violence, as from a blow on the chin.

Symptoms and Signs.—Pain, swelling, mobility, crepitus, irregularity of the teeth, or depression of the malar bone if the antrum is involved.

Complications.—Concussion of the brain, injury to the lachrymal duct or infraorbital nerve, and hemorrhage.

Treatment.—Fragments of the alveolar process may be held in place by wiring the teeth together or inserting an interdental splint, or the lower jaw may be used as a splint, keeping it firmly closed against the upper jaw by means of a four-tailed or Barton's jaw bandage. Repair takes place in from four to six weeks.

FRACTURES OF THE INFERIOR MAXILLA are most common between the ages of twenty and thirty, may be compound through the skin or mucous membrane, may involve any part of the bone,—the alveolar, condyloid, or coronoid processes, the body or ramus,—and may be single or multiple. The most common point of complete fracture is at or near the median line (Gurlt).

The *cause* is usually direct violence, sometimes indirect violence, as by a blow on the chin, causing fracture of the condyloid process.

Symptoms and signs are irregularity of the teeth, abnormal point of motion, crepitus, pain, and tenderness. When the condyloid process is broken the chin may be drawn towards the injured side, while the condyle is drawn inward and forward by the external pterygoid muscle.

Complications are loose teeth, suppuration, necrosis, injury to the inferior dental nerve, bleeding from the ears, or concussion of the brain.

Treatment.—Reduce the fracture and keep in position by wiring the teeth, passing the wire two teeth from the line of fracture on either side; by an interdental splint, or by the use of splints moulded to the chin and jaw, composed of pasteboard, leather, or plaster of Paris, held in place by a four-tailed or Barton's jaw bandage, keeping the lower jaw firmly closed against the upper jaw as a splint.

Feed the patient on liquids. Union takes place in from six to eight weeks. Occasionally *delayed union* occurs.

FRACTURE OF THE HYOID BONE is rare, and usually occurs in the greater cornu near its junction with the body, from hanging, blows, or being grasped by the throat.

Symptoms and Signs.—Pain on speaking, swallowing, or moving the tongue; hoarse voice; cough; abnormal point of motion; and sometimes hemorrhage. Swelling and œdema of the glottis may follow.

Treatment.—Attempt to reduce the fragments and prevent swallowing as much as possible, using an œsophageal tube. Œdema of the glottis would require tracheotomy.

FRACTURES OF THE STERNUM are simple or compound, complete or incomplete, single or multiple, transverse, oblique, or horizontal, and occur most frequently at the junction of the manubrium with the gladiolus, as a result of direct or indirect violence or muscular action. Indirect violence may act by forcibly bending the body forward or backward. Muscular action has been known to produce fracture, as by straining during labor or in lifting a heavy body.

Symptoms and Signs.—Pain and tenderness on pressure, crepitus, abnormal point of motion, sometimes overriding, cough, and expectoration of blood.

Complications.—Pressure on the lung or heart, or suppuration in the anterior mediastinum.

Treatment.—Reduce by pressure on the projecting fragment, aided, if necessary, by bending the patient backward over a pillow. If reduction is impossible and pressure symptoms exist, operate and pry the bone into place. After reduction the chest may be fixed by a circular bandage or adhesive plaster. Union usually takes place in about six weeks in simple cases. The prognosis is serious.

FRACTURES OF THE RIBS constitute about 16 per cent. of all fractures, and are more frequent in adults and old persons. The rib most frequently broken is the seventh; the most common point, about the angle.

The *varieties* are simple or compound, single or multiple, complete or incomplete.

The *causes* are direct or indirect violence, muscular action, and, rarely, coughing.

Symptoms and Signs.—Pain, which is increased on inspiration; cough; tenderness; crepitus; and an abnormal point of motion. Crepitus may be felt by the hand or heard by the ear applied to the chest while the patient breathes. There is seldom displacement unless several ribs are broken or the fracture be the result of direct violence.

Complications are surgical emphysema from wounding of the lung, pneumothorax from the same cause or from compound fracture through the skin, hæmoptysis or hæmothorax from the lungs or from an intercostal artery.

Treatment.—Fix the chest and prevent pain by strapping one-half of the entire chest, from axilla to ensiform cartilage, with broad strips of adhesive plaster applied during expiration. Pressure of a fragment on the lung should be relieved by operation. Hemorrhage may be arrested by pressure or ligation. Air or blood in the pleural cavity, producing serious symptoms, may be removed by aspiration or thoracotomy. Fractures of the ribs usually unite in from four to six weeks.

FRACTURE OF THE COSTAL CARTILAGES is seen in the aged. Diastasis may take place at the junction of the cartilage with the sternum or with the rib. Repair usually takes place by means of bone.

FRACTURE OF THE CLAVICLE.—The clavicle is broken more frequently than any other bone in the body (Gurlt). It occurs at any age, but half the cases occur in children under six years of age. The most common point of fracture is the middle third near its junction with the outer third, next the acromial end, and last the sternal end.

The *varieties* are simple or compound, complete or incomplete (greenstick), multiple or comminuted, single or double, and oblique or transverse.

Etiology.—Direct or indirect violence and muscular action. A fall on the shoulder, which would produce a dislocation of the shoulder in an adult, fractures the clavicle in a child. The line of fracture, when oblique, runs from above inward and downward or backward, so that the point of the outer fragment underlies that of the inner one. Fracture of the outer third between the attachment of the coracoclavicular ligament gives little or no displacement.

Symptoms and Signs.—The patient leans his head towards the affected side and supports the elbow with the other hand. There are pain and loss of function, crepitus, an abnormal point of motion, and displacement. The shoulder drops downward, forward, and inward. In *incomplete* or *green-stick* fractures the symptoms are obscure and the diagnosis must be made, in the absence of deformity, by the age, pain, tenderness, some loss of function, and, possibly, yielding of the bone at one point on pressure.

Complications are rare. A few cases are reported of injury to the brachial plexus, the lungs, the internal jugular vein, or subclavian vessels.

The prognosis as to union and function is good, but shortening is the rule.

Treatment.—Reduce the fracture by moving the shoulder *upward*, *backward*, and *outward* and pressing the ends of the bone into position. In *greenstick* or incomplete fractures do not attempt reduction, but simply apply an apparatus to prevent motion. The great difficulty is to keep the shoulder and scapula in position. Several methods are used.

The Recumbent Position.—Keep the patient in bed three weeks, on his back, with a firm narrow pillow between the shoulders, with the head slightly flexed so as to relax the sternomastoid muscle, and the arm and forearm bound to the side and front of the chest by means of circular turns of a bandage.

Sayre's Method.—Cut two strips of adhesive plaster, each three or four inches in width and about two yards in length. The end of one

FIG. 126.—Sayre's method of dressing fracture of the clavicle.

strip encircles the arm of the affected side just below the axilla, forming a loop which does not compress the blood-vessels; the other end is carried around the back, beneath the axilla to the front of the chest, or entirely around to the back, so as to draw the elbow a little back of the axillary line. While the elbow is pressed *forward*, *inward*, and *upward*, the second strip is applied, beginning on the shoulder of the sound side, passing diagonally across the back, beneath the elbow of the affected side, along the forearm, to be attached to its point of origin. A roller bandage is applied by circular turns about the chest and arm. Cotton or linen is placed so as to

prevent cutaneous surfaces from coming in contact, and the elbow should be padded to prevent excoriation.

The Velpeau Dressing.—The hand of the injured side is placed on the opposite shoulder, with a small pad in the axilla and a layer of

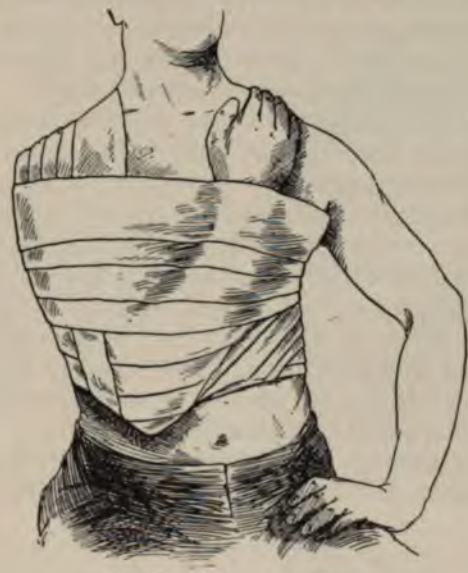

FIG. 127.—Velpeau's bandage.

cotton between the arm and forearm and the chest, and the Velpeau bandage applied.

Moore's Dressing.—Take a piece of cotton cloth, about two yards long and ten or twelve inches wide; place the centre of this bandage across the palm of the hand which seizes the elbow of the patient; the end of the bandage inward towards the patient is then carried in front of the shoulder of the affected side and over the back to the opposite axilla, where it is held by an assistant. The outer end is carried across the forearm at the bend of the elbow, between the arm and the chest, across the back, over the shoulder of the opposite side, where it is fastened to the other end. The forearm is carried in a sling.

The figure-of-8 dressing, suitable for fractures of the outer portion of the clavicle, is applied by making a figure of 8 with a roller bandage, which crosses and makes compression over the clavicle at the point of fracture, and passes alternately beneath the elbow of the affected side and around the chest, through the axilla of the opposite side.

Method by Operation.—This is the only way to get recovery without deformity and may be necessary on account of pressure of fragments on the blood-vessels or nerves. An incision is made over the bone and the fragments are adjusted and held in place by encircling them with several coarse strands of kangaroo tendon, or silver wire, applied by means of a large curved needle. The arm is then bound to the chest by circular turns of a bandage. The writer has used this method in several cases, with excellent results.

FRACTURES OF THE SCAPULA form less than one per cent. of all fractures, and may occur in the body of the bone, including the superior and inferior angles, the spine, the acromion process, the coracoid process, the surgical neck, and the glenoid cavity.

The *causes* are *direct violence*, as by a blow on the shoulder; *indirect violence* transmitted through the humerus; or *muscular action* from contraction of the deltoid, biceps, etc.

In fractures of the surgical neck the line of fracture may pass through the suprascapular notch to the axillary border, or, beginning in front of the coracoid process or within the articular border, pass obliquely downward to the axillary border.

Symptoms and Signs.—In fractures of the *body* crepitus may be detected by placing the hand flat on the body of the bone while the

FIG. 128.—Fracture of the body of the scapula.

FIG. 129.—Fracture of the acromion process. (Wharton and Curtis.)

arm is moved in various directions. An abnormal point of motion or irregularity may be discovered by palpation, by passing the fingers along the vertebral border, or by grasping the inferior angle and moving it. Fractures of the *spine* and *acromion* can easily be detected by crepitus or abnormal mobility. Fracture of the *coracoid process* is indicated by pain on flexing the forearm, from contraction

of the biceps, tenderness on pressure, and the detection of mobility or crepitus by deep pressure. In fracture of the *neck* there is flattening of the shoulder with abnormal prominence of the acromion process. The arm may be lengthened from the acromion to the elbow. The deformity is easily corrected by lifting the elbow, but

FIG. 130.—Fracture of the coracoid process of the scapula.

FIG. 131.—Fracture of the neck of the scapula.

recurs on dropping it, thus differing from dislocation. The coracoid process may be found to move with the head of the humerus and crepitus is usually elicited during manipulation. Fractures of the *glenoid cavity*, unless they involve the neck of the bone, are difficult of diagnosis. Crepitus may be obtained, or the Roentgen ray may reveal the nature of the injury.

Treatment.—In fractures of the *body* and the *spine*, after reduction apply a broad pad over the site of the fracture, hold in place with adhesive plaster, and bind the arm to the side of the chest. Fractures of the *acromion process* and *neck* should be treated by an axillary pad and the figure-of-8 bandage from the elbow, crossing on the top of the shoulder through the opposite axilla and return. When the *coracoid* process is fractured, the Velpeau dressing places the parts in the best position for repair. Union is usually sufficiently firm to dispense with the dressing at the end of six or eight weeks.

FRACTURES OF THE HUMERUS.—Fractures of the humerus constitute about eight per cent. of all fractures, and include those of the upper extremity, lower extremity, shaft, and epiphyseal separation.

FRACTURES OF THE UPPER EXTREMITY include the head of the bone, the anatomical neck, the surgical neck, the tuberosities, and epiphyseal separation.

The *head* of the bone may be *chipped*, *fissured*, or partially *fractured*. In fracture of the *anatomical neck* the line corresponds with

FIG. 132.—Intracapsular fracture of the neck of the humerus. (Malgaigne.)

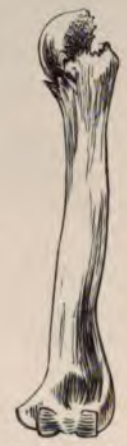

FIG. 133.—Impacted intracapsular fracture of the humerus.

FIG. 134.—Fracture through the anatomical neck of the humerus.

FIG. 135.—Fracture through the surgical neck of the humerus.

the groove which separates the head of the bone from the tuberosities, or passes obliquely into the shaft of the bone, including one or

FIG. 136.—Transverse fracture of the humerus.

FIG. 137.—Epiphyseal separation of the upper end of the humerus.

both of the tuberosities. It may be a complication of anterior dislocation of the shoulder. The *cause* is direct violence, as a blow, or

fall striking on the shoulder, especially in old persons. In fracture of the *surgical neck* the line of fracture passes between the tuberosities above and the insertion of the pectoralis major and teres major below,—the most common fracture of the upper end of the bone. The *cause* is usually a direct blow on the arm or shoulder, sometimes a fall on the elbow, and rarely muscular action. Fractures of the *tuberosities* may occur with fracture of the anatomical neck or sepa-

FIG. 138.—Fracture of the surgical neck of the humerus: 1, deltoid muscle; 2, pectoralis major, turned down from its origin; 3, latissimus dorsi, attached to the humerus; 4, subscapularis muscle; 5, supraspinatus muscle.

rately. The *cause* is direct violence or muscular action. *Epiphyseal* separation occurs in persons under twenty years of age, the tuberosities being detached with the head of the bone.

Symptoms and Signs.—In fracture of the *anatomical neck* there are, besides the usual signs, prominence of the acromion and flattening of the shoulder, if there is displacement, caused by the upper end of the lower fragment being drawn inward by the action of the pectoralis major, shortening of the arm probably half an inch, and crepitus on rotation. When impaction occurs there is no crepitus, but there may be slight shortening and deviation in the normal axis of the humerus. In fracture of the *surgical neck* there are *crepitus*, unless impacted, and an *abnormal point of motion*. In *oblique* fractures there is shortening of about one inch, the lower fragment being drawn upward, inward, and forward. In fracture of the *greater tuberosity* there is *broadening* of

the joint, *crepitus* may be produced, and the tuberosity may be felt as a loose fragment. In *epiphyseal separation* an *abnormal point of motion* and *soft crepitus* may be obtained, and a prominence is seen on the front of the shoulder just below the acromion, caused by the projection of the upper end of the shaft.

Complications.—In detachment of the head at the *anatomical neck* union often fails to take place, or the callus produced may impede the function of the joint. In fractures of the *surgical neck* the long head of the biceps, axillary vessels, and nerves may be injured. *Epiphyseal separation* may arrest growth of the humerus.

Treatment.—In fracture of the *anatomical neck* or of the *head*, fix the arm by binding it to the chest for six or eight weeks. Should ankylosis follow, excise the head of the bone. In fractures of the *surgical neck* reduce by extension and counter-extension, and apply a roller bandage from the fingers to the shoulder. Place a thick layer of cotton from the axilla to the elbow on the side of the chest, and bring the arm against it. Apply a shoulder-cap long enough to extend from above the shoulder-joint to the lower third of the arm and wide enough to include half the circumference of the arm, and hold in place by a roller bandage around the chest and arm. Put the forearm in a sling. The dressings should be worn for six or eight weeks and changed once a week. Extension may be produced in oblique fractures after the manner of Buck's extension,—attaching a weight of from three to five pounds to the elbow. Care should be taken not to produce over-extension. *Detachment of the greater tuberosity* may be treated by pressing the fragment into position and securing by compresses and adhesive plaster, or by operation. The result is commonly union by fibrous tissue. *Epiphyseal separation* must be reduced under anæsthesia and the arm fixed in Velpeau's position, or reposition effected by open operation.

FRACTURE OF THE SHAFT OF THE HUMERUS includes fractures between the attachment of the pectoralis major and the upper portion of the supracondylar ridges, and may occur above or below the attachment of the deltoid muscle. The *lower* half is more frequently affected, the fracture being usually oblique, downward and outward. In the *upper* half transverse fracture is more frequent. The *causes* are external violence, direct or indirect, and muscular action, as from throwing a stone.

Symptoms and Signs.—There is usually shortening of about one inch, an abnormal point of motion, crepitus, and angular deformity. The displacement depends on the location of the fracture. In the *upper* half the upper fragment is drawn inward by the chest muscles and the lower fragment outward by the deltoid. In the *lower* half

the upper fragment is drawn outward and somewhat forward by the deltoid and pectoralis major, while the lower fragment is drawn upward and backward by the triceps and biceps.

Complications are injury to the musculospiral nerve, primarily or by pressure from the callus during repair; gangrene, from injury to the blood-vessels; and non-union.

Treatment.—Reduce the fragments, apply a roller bandage from fingers to axilla, and place the arm and forearm on a well-padded

FIG. 139.—Dressing for fracture of the shaft of the humerus.

FIG. 140.—Fracture of the lower third of the humerus, with overlapping.

internal angular splint extending from the axilla to the end of the fingers. A shoulder-cap extending to the elbow should then be applied, and the arm fixed to the chest by a roller bandage, the forearm being carried in a sling.

FRACTURES OF THE LOWER EXTREMITY are supracondylar, intercondylar, condylar, epicondylar, and epiphyseal separation. The *causes* are direct or indirect violence. In *supracondylar* fracture the line of separation passes tranversely or obliquely through the expanded portion of the bone above the condyles. In *intercondylar*, *T-shape*, or *Y-shape* fracture the transverse line above the condyles is joined by another passing vertically between them. *Condylar* fractures may affect either condyle, the line of fracture running obliquely downward into the trochlear surface or to the inner side of the capitellum. Either *epicondyle* may be detached, the internal more fre-

quently. It occurs in children as an epiphyseal separation, the result of direct violence or musuclar action. In *epiphyseal separation* the articular surface of the bone, including the trochlea, capitellum humeri, condyles, and epicondyles, may be detached from the shaft altogether or in part.

Symptoms and Signs.—In *supracondylar* fracture there are pain, mobility, crepitus, shortening of the humerus, and displacement of the lower fragment, with the olecranon, backward, while the upper

FIG. 141.—Supracondylar fracture of the humerus; characteristic displacement of the fragments.

FIG. 142.—T-fracture of the condyles of the humerus. (Wharton and Curtis.)

fragment projects in front of the joint, where it may be felt. In *intercondylar* or *T-fracture* the joint is increased in breadth and the condyles move independently, one on the other and on the shaft of the bone, with crepitus. *Epiphyseal separation* occurs in the young, the line of separation is apt to be transverse above the epicondyles or obliquely between the two, and the crepitus is soft. Fracture of the *condyles* is detected by mobility and crepitus.

Complications may be ankylosis from involvement of the joint, injury of the ulnar or median nerve, or of the brachial artery.

Treatment.—Care is necessary to prevent ankylosis or deformity, cubitus varus, "gunstock deformity,"—an abnormal inclination of the forearm to the ulnar side, so that the "carrying power" is

impeded. Occasionally the opposite deformity, cubitus valgus, is seen. They may occur in condylar or supracondylar fractures, from the elevation or lowering of either condyle. Anæsthesia is generally necessary to permit a thorough examination and the proper treatment. After reduction, place the arm and forearm on a well-padded internal angular splint or a posterior rectangular gutter splint. It is often better to set the arm in the extended position, using a well-padded anterior splint and changing to a right angle after two weeks, as this method is less likely to be followed by cubitus varus. The splint should be removed at least weekly for bathing and to detect displacement and to make general motion of the joint to prevent ankylosis. The forearm may be fixed in a position of *acute flexion* after reduction of the fragments, and gradually extended after union. When possible, after the adjustment of the dressing an examination should be made with the Roentgen ray, to determine the

FIG. 143.—Cubitus varus, or "gunstock deformity," after fracture of the lower extremity of the humerus.

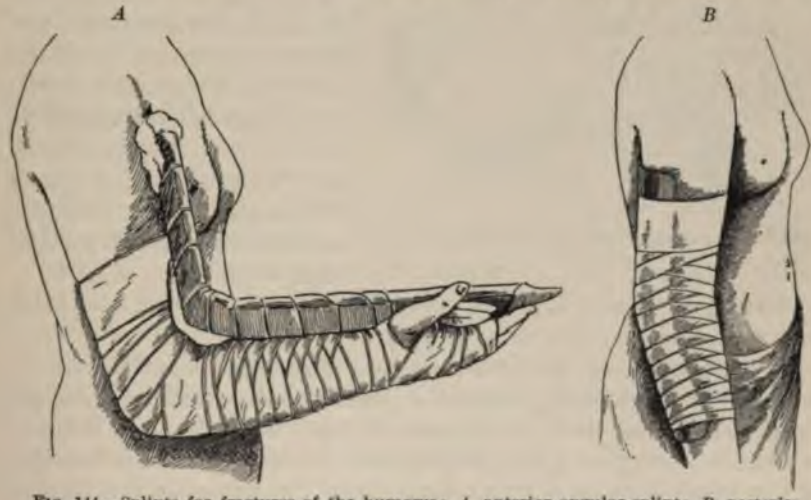

FIG. 144.—Splints for fractures of the humerus: *A*, anterior angular splint; *B*, posterior gutter splint.

position of the fragments. When it is impossible to reduce or hold the fragments in position, expose by incision and fasten by means

of drills, nails, kangaroo tendon, or silver wire, as practised by Allis, Roberts, the writer, and other surgeons. The incision may be made posteriorly through the triceps muscle, or anteriorly between the biceps and the supinator longus. If ankylosis appear inevitable, flexion at about a right angle gives the most serviceable position for the patient.

FRACTURE OF THE FOREARM.—Fractures of the forearm may be divided into fractures of both bones, of the ulna alone, of the radius alone, and epiphyseal separation.

FRACTURES OF BOTH BONES may take place in the upper, middle, or lower third, most frequently in the middle third. The *causes* are direct or indirect force, as a blow on the forearm or force transmitted from the hand or elbow.

FIG. 145.—Dressing for fracture of both bones of the forearm.

Symptoms and Signs.—Angular deformity, abnormal mobility, crepitus, and shortening make the diagnosis easy. If the fracture occur above the insertion of the pronator radii teres, the upper fragment of the radius is apt to be supinated and flexed, as the action of the biceps and supinator brevis is no longer counteracted by that of the two pronators. In "greenstick" fractures the bones may be bent to a considerable extent without separating.

Complications are excessive callus, impeding pronation and supination, and occasionally delayed union.

Treatment.—Flex the forearm, reduce the fragments, and place the limb on a well-padded, internal angular splint extending from the axilla to the hand, with the forearm midway between pronation and supination, thus giving the greatest interosseous width. In fractures of the *upper third* (above the insertion of the pronator radii teres) place the forearm in supination and keep in this position by a light plaster bandage extending from the hand half-way up the arm, or a posterior right-angled gutter splint with an anterior splint of paste-

board or thin wood on the front of the forearm. Have the splints wide enough to prevent encroachment upon the interosseous space, and see that the anterior splint does not press on the brachial artery at the bend of the elbow. No bandage should be applied beneath the splints and the circulation should be carefully watched after applying the dressing. In oblique fractures some shortening is inevitable unless open operation be done. Change the splints weekly, or oftener, until union takes place, usually in from six to eight weeks. In "green-stick" fractures gently straighten the bone and apply a light splint. Use an interosseous pad on the dorsum if there is a tendency to encroachment on the interosseous space. This may be made of cotton batting twisted into a small rope, or of a section of bandage rolled lengthwise.

FRACTURE OF THE ULNA occurs in the *upper end*, the *olecranon* and *coronoid* processes, the *shaft*, and the *lower end*, including the *styloid* process, as a result of direct or indirect violence and muscular action. The *olecranon* may break at its beak, at the insertion of the triceps, or at its base through the greater sigmoid cavity. The *coronoid process* is rarely broken except as a complication of backward dislocation of the ulna. The shaft may be broken in the upper, middle, or lower third, most frequently near the junction of the middle and lower thirds.

Symptoms and Signs.—In fracture of the *olecranon* a movable fragment is detected, with more or less separation from the rest of the bone, and crepitus if the fragments can be brought together, and sometimes inability to extend the forearm. Fracture of the *coronoid process* may be suspected in backward dislocation of the ulna if the dislocation easily recurs after reduction. A movable fragment may be felt on the front of the elbow-joint. Fractures of the *shaft* are easily detected on account of the superficial situation of the bone. Fracture of the *styloid process* is indicated by pain, swelling, crepitus, and abnormal mobility, especially on abducting the hand.

Complications may be ankylosis after fractures of the *olecranon*, or fibrous union. Fractures of the shaft may be complicated by forward dislocation of the head of the radius.

Treatment.—In fractures of the *olecranon*, with no separation, or if the upper fragment can be brought into proper position, retain it by applying a compress above, held in place by strips of adhesive plaster crossing the forearm below the elbow. The forearm is carried in a sling at right angles or midway between right angles and extension. When reduction cannot be maintained, or in compound fractures, or in old fracture with ligamentous union and loss of function, expose the bones and unite them with silver wire, kangaroo tendon, drills,

or nails,—preferably by kangaroo tendon,—uniting the periosteum and ligamentous attachments; or by a drill passed longitudinally through the upper fragment into the lower, with the end left projecting through the skin for removal after union. Short fibrous union does not seriously impair the functions of the joint. Treat fractures of the *coronoid* process by flexure of the forearm or the Velpeau position. Fractures of the *shaft* of the ulna are treated like fractures of both bones. In fracture of the *styloid* process keep the fragment in place by compresses and adhesive plaster.

FRACTURE OF THE RADIUS occurs in the head, neck, shaft, or lower end, most frequently in the lower end. Epiphyseal separation is sometimes seen at this point. Fractures of the *head* and *neck* are rare, and may be caused by *indirect* force with backward dislocation of the elbow or by *direct* force. The head may divide into two or more fragments, or split off from the neck transversely or obliquely. Fractures of the *lower extremity* of the radius include Colles's fracture, reversed Colles's fracture, Barton's fracture, fractures of the styloid process, and epiphyseal separation. In *Colles's fracture*, the most common fracture of the radius, the line of fracture is usually transverse, but may be oblique, and is located from one-third of an inch to one inch above the articular border, and sometimes corresponds with the epiphyseal junction. The lower fragment may be comminuted, and

FIG. 146.—Deformity after fracture of the radius.

FIG. 147.—"Silver-fork" deformity (Colles's fracture).

impaction may take place from crushing or penetration of the lower by the upper fragment. The lower fragment may be displaced directly backward without being tilted, but usually it is tilted so that the articulating surface looks downward and backward instead of downward, as it does normally. It is caused by a fall, striking on

the palm of the hand. The *reversed Colles's fracture* is similar to the one just described, but is caused by a fall on the *back* of the hand, producing forced flexion. The lower fragment is displaced forward and the articular surface looks abnormally forward. *Barton's fracture* is the chipping off of the posterior lip of the articular surface of the radius. A similar fracture may affect the anterior lip. In either case it seems to be the result of a backward or forward dislocation of the carpus. In fracture of the *styloid* process a portion of the adjoining bone is usually separated with the process.

FIG. 148.—Deformity after arrest of growth of the radius from epiphysitis.

Symptoms and Signs.—Fractures of the *head* of the radius give the usual symptoms of fracture. In fracture of the *neck* the head fails to rotate with the shaft in pronation and supination. Fractures of the *shaft* are easily detected by the ordinary symptoms and signs. *Colles's fracture* is indicated by the "silver-fork" deformity; abduction of the hand; abnormal prominence of the styloid process of the ulna; the styloid process of the radius, instead of being a quarter of an inch below that of the ulna, is found at the same level or above it; and abnormal mobility and crepitus, except in impacted fractures. In reversed *Colles's fracture* there is a prominence on the dorsal surface about three-fourths of an inch above the joint, with a depression below, while on the palmar surface there is a depression above with an abnormal prominence below. *Barton's fracture* and fracture of the *styloid* process may be recognized by detecting a movable fragment, possibly with crepitus. *Epiphyseal separation* is probable if the patient is a child, the line of fracture transverse and near the joint, and the crepitus soft in character.

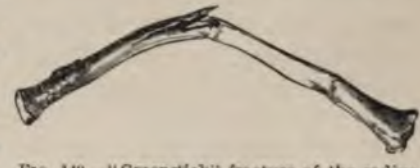

FIG. 149.—"Greenstick" fracture of the radius. (A variety of incomplete fracture.)

Complications may be ankylosis of the wrist, stiffness of the flexor tendons, and abnormal radial deviation of the hand, with prominence of the styloid process of the ulna, which may be permanent from failure to reduce the displacement, or in adults from shortening of the radius by crushing, or in young persons from arrested growth in the length of the radius due to injury to the epiphysis.

Treatment.—In fractures of the *head* and *neck*, after reduction fix

the forearm in acute flexion or in the Velpeau position. The head should be excised if, after recovery, function is impeded. In fractures of the *shaft*, treat as in fracture of both bones.

In the *treatment of Colles's fracture* the most important point is to make sure of complete reduction. Give an anæsthetic and break up the impaction, should it exist, and restore the displaced fragment to its normal position. If by extension and manipulation it is impossible to effect reduction, bend the hand backward, increasing the deformity, press the lower fragment downward towards the wrist, and then by sudden flexion of the hand bring it into position. There is little tendency to recurrence of the displacement after complete reduction, unless the fracture is oblique or comminuted, so that any dressing which keeps the forearm still is sufficient, as a strip of adhesive plaster three inches wide wrapped around the wrist three or four times. Anterior and posterior splints extending from a short distance below the elbow to the wrist-joint, or a light plaster-of-Paris bandage extending from the wrist three or four inches up the forearm, may be used. In oblique or comminuted fractures use a splint which keeps the hand deviated towards the ulnar side, such as Bond's splint,

FIG. 150.—Bond's splint for fracture of the lower end of the radius.

which is an ordinary board with a block fixed obliquely at the lower end to fit the palm of the hand and to hold it in the position of ulnar deviation. Compresses over the fragments under the splints are unnecessary and may be injurious. In young persons the splints may extend to the ends of the fingers, but in the old, or those of a rheumatic tendency, they should not extend far enough to interfere with the movements of the fingers, as stiffness is apt to result. In simple cases union takes place in from four to six weeks.

FRACTURES OF THE HAND.—Fractures of the hand include the carpus, metacarpus, and phalanges, the phalanges being most frequently affected.

Fractures of the *carpal bones* are usually compound and the result of direct violence, as the action of machinery or gunshot wounds. Fractures of the metacarpal bones and phalanges are more common, especially the metacarpal bone of the forefinger.

The *causes* are direct or indirect violence. The *symptoms* are

obvious. The lower end of the upper fragment is usually displaced towards the palm.

Treatment.—In fractures of the *metacarpal bones*, reduce and place the hand and forearm on a palmar splint with a ball of cotton, or of some other material, large enough to fit the palm of the hand. Union takes place in from three to five weeks. In *compound fractures* of the hand the greatest care should be taken to disinfect the wound and to prevent infection during the process of healing. Fractures of the phalanges often require amputation, but in case of doubt the weight of it should be thrown on the side of conservatism, especially in dealing with the thumb.

FIG. 151.—Skiagram of a fractured phalanx.

FRACTURES OF THE PELVIS.—Fractures of the pelvis may involve the ilium, ischium, pubis, sacrum, or coccyx. The ring of the pelvis may be broken in one or more places, most frequently through the body or rami of the pubes, or simply a portion of the iliac crest may be chipped off. Sometimes the head of the femur is driven into the acetabulum with such force as to fracture it, and may even pass through it into the pelvic cavity. The most serious fractures are those which involve the ring of the pelvis, the gravity depending on associated injury to the pelvic viscera. *Causes* are direct or indirect force, such as the kick of a horse, a fall, or some crushing injury.

Symptoms and Signs.—Fractures of the *sacrum* or *coccyx* can be detected by palpation externally and with the finger in the rectum. There may be symptoms of interference with urination and defecation. In fractures of the *ilium* and *ischium* there is pain or inability to stand or walk. Crepitus and abnormal mobility may be detected by grasping the crests of the ilia and moving them. In fracture of the *pubis* injury to the urethra or bladder is a frequent complication.

Complications may be paralysis from injury to the sacral plexus, or laceration of the bladder, urethra, intestines, and large blood-vessels.

Treatment.—When the pubic ring is broken make an attempt to reduce the fragments, immobilize the pelvis with a plaster-of-Paris or an ordinary roller bandage, and keep the patient in bed for six or eight weeks. Complications require special treatment. If the *coccyx* give trouble it should be excised. In fracture of the *os pubis* reduction

the forearm in acute flexion or in the Velpeau position. The head should be excised if, after recovery, function is impeded. In fractures of the *shaft*, treat as in fracture of both bones.

In the *treatment of Colles's fracture* the most important point is to make sure of complete reduction. Give an anæsthetic and break up the impaction, should it exist, and restore the displaced fragment to its normal position. If by extension and manipulation it is impossible to effect reduction, bend the hand backward, increasing the deformity, press the lower fragment downward towards the wrist, and then by sudden flexion of the hand bring it into position. There is little tendency to recurrence of the displacement after complete reduction, unless the fracture is oblique or comminuted, so that any dressing which keeps the forearm still is sufficient, as a strip of adhesive plaster three inches wide wrapped around the wrist three or four times. Anterior and posterior splints extending from a short distance below the elbow to the wrist-joint, or a light plaster-of-Paris bandage extending from the wrist three or four inches up the forearm, may be used. In oblique or comminuted fractures use a splint which keeps the hand deviated towards the ulnar side, such as Bond's splint,

FIG. 150.—Bond's splint for fracture of the lower end of the radius.

which is an ordinary board with a block fixed obliquely at the lower end to fit the palm of the hand and to hold it in the position of ulnar deviation. Compresses over the fragments under the splints are unnecessary and may be injurious. In young persons the splints may extend to the ends of the fingers, but in the old, or those of a rheumatic tendency, they should not extend far enough to interfere with the movements of the fingers, as stiffness is apt to result. In simple cases union takes place in from four to six weeks.

FRACTURES OF THE HAND.—Fractures of the hand include the carpus, metacarpus, and phalanges, the phalanges being most frequently affected.

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The *causes* are direct or indirect violence. The *symptoms* are

obvious. The lower end of the upper fragment is usually displaced towards the palm.

Treatment.—In fractures of the *metacarpal bones*, reduce and place the hand and forearm on a palmar splint with a ball of cotton, or of some other material, large enough to fit the palm of the hand. Union takes place in from three to five weeks. In *compound fractures* of the hand the greatest care should be taken to disinfect the wound and to prevent infection during the process of healing. Fractures of the phalanges often require amputation, but in case of doubt the weight of it should be thrown on the side of conservatism, especially in dealing with the thumb.

FIG. 151.—Skiagram of a fractured phalanx.

FRACTURES OF THE PELVIS.—Fractures of the pelvis may involve the ilium, ischium, pubis, sacrum, or coccyx. The ring of the pelvis may be broken in one or more places, most frequently through the body or rami of the pubes, or simply a portion of the iliac crest may be chipped off. Sometimes the head of the femur is driven into the acetabulum with such force as to fracture it, and may even pass through it into the pelvic cavity. The most serious fractures are those which involve the ring of the pelvis, the gravity depending on associated injury to the pelvic viscera. *Causes* are direct or indirect force, such as the kick of a horse, a fall, or some crushing injury.

Symptoms and Signs.—Fractures of the *sacrum* or *coccyx* can be detected by palpation externally and with the finger in the rectum. There may be symptoms of interference with urination and defecation. In fractures of the *ilium* and *ischium* there is pain or inability to stand or walk. Crepitus and abnormal mobility may be detected by grasping the crests of the ilia and moving them. In fracture of the *pubis* injury to the urethra or bladder is a frequent complication.

Complications may be paralysis from injury to the sacral plexus, or laceration of the bladder, urethra, intestines, and large blood-vessels.

Treatment.—When the pubic ring is broken make an attempt to reduce the fragments, immobilize the pelvis with a plaster-of-Paris or an ordinary roller bandage, and keep the patient in bed for six or eight weeks. Complications require special treatment. If the *coccyx* give trouble it should be excised. In fracture of the *os pubis* reduction

the forearm in acute flexion or in the Velpeau position. The head should be excised if, after recovery, function is impeded. In fractures of the *shaft*, treat as in fracture of both bones.

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FIG. 150.—Bond's splint for fracture of the lower end of the radius.

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The *causes* are direct or indirect violence. The *symptoms* are

obvious. The lower end of the upper fragment is usually displaced towards the palm.

Treatment.—In fractures of the *metacarpal bones*, reduce and place the hand and forearm on a palmar splint with a ball of cotton, or of some other material, large enough to fit the palm of the hand. Union takes place in from three to five weeks. In *compound fractures* of the hand the greatest care should be taken to disinfect the wound and to prevent infection during the process of healing. Fractures of the phalanges often require amputation, but in case of doubt the weight of it should be thrown on the side of conservatism, especially in dealing with the thumb.

FIG. 151.—Skiagram of a fractured phalanx.

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Symptoms and Signs.—Fractures of the *sacrum* or *coccyx* can be detected by palpation externally and with the finger in the rectum. There may be symptoms of interference with urination and defecation. In fractures of the *ilium* and *ischium* there is pain or inability to stand or walk. Crepitus and abnormal mobility may be detected by grasping the crests of the ilia and moving them. In fracture of the *pubis* injury to the urethra or bladder is a frequent complication.

Complications may be paralysis from injury to the sacral plexus, or laceration of the bladder, urethra, intestines, and large blood-vessels.

Treatment.—When the pubic ring is broken make an attempt to reduce the fragments, immobilize the pelvis with a plaster-of-Paris or an ordinary roller bandage, and keep the patient in bed for six or eight weeks. Complications require special treatment. If the *coccyx* give trouble it should be excised. In fracture of the *os pubis* reduction

the forearm in acute flexion or in the Velpeau position. The head should be excised if, after recovery, function is impeded. In fractures of the *shaft*, treat as in fracture of both bones.

In the *treatment of Colles's fracture* the most important point is to make sure of complete reduction. Give an anæsthetic and break up the impaction, should it exist, and restore the displaced fragment to its normal position. If by extension and manipulation it is impossible to effect reduction, bend the hand backward, increasing the deformity, press the lower fragment downward towards the wrist, and then by sudden flexion of the hand bring it into position. There is little tendency to recurrence of the displacement after complete reduction, unless the fracture is oblique or comminuted, so that any dressing which keeps the forearm still is sufficient, as a strip of adhesive plaster three inches wide wrapped around the wrist three or four times. Anterior and posterior splints extending from a short distance below the elbow to the wrist-joint, or a light plaster-of-Paris bandage extending from the wrist three or four inches up the forearm, may be used. In oblique or comminuted fractures use a splint which keeps the hand deviated towards the ulnar side, such as Bond's splint,

FIG. 150.—Bond's splint for fracture of the lower end of the radius.

which is an ordinary board with a block fixed obliquely at the lower end to fit the palm of the hand and to hold it in the position of ulnar deviation. Compresses over the fragments under the splints are unnecessary and may be injurious. In young persons the splints may extend to the ends of the fingers, but in the old, or those of a rheumatic tendency, they should not extend far enough to interfere with the movements of the fingers, as stiffness is apt to result. In simple cases union takes place in from four to six weeks.

FRACTURES OF THE HAND.—Fractures of the hand include the carpus, metacarpus, and phalanges, the phalanges being most frequently affected.

Fractures of the *carpal bones* are usually compound and the result of direct violence, as the action of machinery or gunshot wounds. Fractures of the metacarpal bones and phalanges are more common, especially the metacarpal bone of the forefinger.

The *causes* are direct or indirect violence. The *symptoms* are

obvious. The lower end of the upper fragment is usually displaced towards the palm.

Treatment.—In fractures of the *metacarpal bones*, reduce and place the hand and forearm on a palmar splint with a ball of cotton, or of some other material, large enough to fit the palm of the hand. Union takes place in from three to five weeks. In *compound fractures* of the hand the greatest care should be taken to disinfect the wound and to prevent infection during the process of healing. Fractures of the phalanges often require amputation, but in case of doubt the weight of it should be thrown on the side of conservatism, especially in dealing with the thumb.

FIG. 151.—Skiagram of a fractured phalanx.

FRACTURES OF THE PELVIS.—Fractures of the pelvis may involve the ilium, ischium, pubis, sacrum, or coccyx. The ring of the pelvis may be broken in one or more places, most frequently through the body or rami of the pubes, or simply a portion of the iliac crest may be chipped off. Sometimes the head of the femur is driven into the acetabulum with such force as to fracture it, and may even pass through it into the pelvic cavity. The most serious fractures are those which involve the ring of the pelvis, the gravity depending on associated injury to the pelvic viscera. *Causes* are direct or indirect force, such as the kick of a horse, a fall, or some crushing injury.

Symptoms and Signs.—Fractures of the *sacrum* or *coccyx* can be detected by palpation externally and with the finger in the rectum. There may be symptoms of interference with urination and defecation. In fractures of the *ilium* and *ischium* there is pain or inability to stand or walk. Crepitus and abnormal mobility may be detected by grasping the crests of the ilia and moving them. In fracture of the *pubis* injury to the urethra or bladder is a frequent complication.

Complications may be paralysis from injury to the sacral plexus, or laceration of the bladder, urethra, intestines, and large blood-vessels.

Treatment.—When the pubic ring is broken make an attempt to reduce the fragments, immobilize the pelvis with a plaster-of-Paris or an ordinary roller bandage, and keep the patient in bed for six or eight weeks. Complications require special treatment. If the *coccyx* give trouble it should be excised. In fracture of the *os pubis* reduction

the forearm in acute flexion or in the Velpeau position. The head should be excised if, after recovery, function is impeded. In fractures of the *shaft*, treat as in fracture of both bones.

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obvious. The lower end of the upper fragment is usually displaced towards the palm.

Treatment.—In fractures of the *metacarpal bones*, reduce and place the hand and forearm on a palmar splint with a ball of cotton, or of some other material, large enough to fit the palm of the hand. Union takes place in from three to five weeks. In *compound fractures* of the hand the greatest care should be taken to disinfect the wound and to prevent infection during the process of healing. Fractures of the phalanges often require amputation, but in case of doubt the weight of it should be thrown on the side of conservatism, especially in dealing with the thumb.

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obvious. The lower end of the upper fragment is usually displaced towards the palm.

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Complications may be paralysis from injury to the sacral plexus, or laceration of the bladder, urethra, intestines, and large blood-vessels.

Treatment.—When the pubic ring is broken make an attempt to reduce the fragments, immobilize the pelvis with a plaster-of-Paris or an ordinary roller bandage, and keep the patient in bed for six or eight weeks. Complications require special treatment. If the *coccyx* give trouble it should be excised. In fracture of the *os pubis* reduction

should be effected by introducing the finger into the rectum or vagina, aided by external manipulation. Then immobilize by a binder or plaster-of-Paris cast. If the bladder or urethra be ruptured, perform perineal section—if the opening involve the peritoneal cavity or intestine, laparotomy.

FRACTURES OF THE FEMUR.—Any part of the bone may be fractured, but in children and adults the shaft and lower extremity, while in the aged the neck, are the parts most frequently involved.

FIG. 152.—Comminuted fracture of the neck of the femur.

FRACTURES OF THE UPPER EXTREMITY OF THE FEMUR include the head, epiphyseal separation, the neck, and the trochanters. Fractures of the *head*

FIG. 153.—Impacted fracture of the neck of the femur. (Miller.)

FIG. 154.—Displacement of the upper fragment of the femur in a fracture of the upper third of the bone.

and *epiphyseal separation* of the head from the upper part of the neck are rare and may be the result of direct or indirect force. Fractures

of the *neck* may occur at the small part near the head (intracapsular fracture) or at the base or large part of the neck (extracapsular fracture). Often the line of fracture is partly within and partly without the capsule; it may be transverse or oblique, and sometimes includes the greater trochanter.

The *causes* are direct or indirect violence, such as blows or falls on the trochanter major or on the knee or foot. Fracture of the *small part* of the *neck* (intracapsular) is by far more frequent in persons past middle life, especially women. It is sometimes produced by

FIG. 155.—Fracture of the upper third of the femur; recovery, with overriding. (Skiagram.)

force of the most trivial character, as a slight misstep, twist of the thigh, or even kneeling. The weakness of the neck is probably due to fatty degeneration or senile atrophy. Fractures of the neck may be associated with crushing, impaction, or comminution. Impaction is more frequent in extracapsular than in intracapsular fracture. Fracture of the *trochanters* may affect either trochanter, and the trochanter minor may be pulled off by the action of the psoas iliacus muscle. The great trochanter is more frequently fractured. The *cause* is a direct blow or muscular action.

Symptoms and Signs.—In fractures of the neck the *function* of the limb is lost or impaired. The *foot* is usually everted, often lying on the outer border while the *thigh* is rotated outward. In impaction there may be no eversion, but even slight inversion may exist. *Allis's sign*—relaxation of the fascia lata between the iliac crest and trochanter and above the outer condyle of the femur—is present if

there is *shortening*. Shortening from a fraction of an inch to two or three inches is detected by measuring from the anterior superior spine of the ilium to the adductor tubercle. On rotating the femur *crepitus* may be obtained and the *arc* of *rotation* described by the trochanter is less than that of the sound side. The *trochanter major* will be found in a higher position than normal with reference to Nélaton's line. Nélaton's line is indicated by a cord stretched from the anterior superior iliac spine to the tuberosity of the ischium. Normally this cord crosses the top of the trochanter. The outer portion of Scarpa's triangle is harder and more resistant than the one on the normal side. The differential diagnosis between the two forms of fracture of the neck of the femur can sometimes be made by observing the following points: Fracture of the small part of the neck is usually seen in old persons, especially women; often the result of trivial force; there is less shortening—half an inch to an inch; and the arc of rotation of the trochanter is greater than in fractures at the base of the neck. An impacted fracture may be mistaken for a contusion, but if, in spite of a careful examination and the use of the Roentgen ray, there is still a doubt, the case should be treated as one of fracture. *Fracture of the great trochanter* is indicated by pain, mobility of the fragment, possibly crepitus, and impairment of external rotation of the thigh.

FIG. 156.—Longitudinal fracture of the femur.

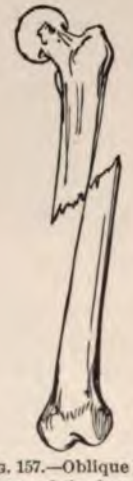

FIG. 157.—Oblique fracture of the femur.

FIG. 158.—Usual deformity in fracture of the shaft of the femur.

FRACTURE OF THE SHAFT OF THE FEMUR occurs in the upper, middle, or lower third, the most common point being the middle

third. Fracture in the upper third is commonly due to indirect violence; in the lower third to direct violence; and in the middle third to direct or indirect violence or muscular action, as by drawing on a tight boot or by kicking at and missing the object.

Symptoms and Signs.—Unnatural mobility, crepitus, and deformity are usually present. There are often overriding and shortening of one to five inches. In the *upper third* the line of fracture usually runs downward, forward, and outward, and the upper fragment is tilted forward and outward, while the lower fragment is drawn upward and inward. In fractures of the *middle* and *lower* thirds the line of fracture is usually from behind downward and forward, so that the upper fragment projects outward and forward, while the lower fragment projects inward and backward. The foot is usually everted, but may be inverted.

FRACTURES OF THE LOWER EXTREMITY OF THE FEMUR include supracondylar; intercondylar, or T-shaped; condylar, where either condyle is fractured; and epiphyseal separation.

In *supracondylar* and *T-shaped* fractures the *cause* is direct violence, as a fall or blow striking on the patella or lower end of the femur. In *condylar fracture* either condyle may be involved, the line of fracture passing for a longer or shorter distance into the shaft of the bone. *Epiphyseal separation* may be caused by direct or indirect violence.

Symptoms and Signs.—In *supracondylar* fracture crepitus, abnormal mobility; if oblique, shortening; the lower fragment is tilted backward into the popliteal space, while the upper fragment presents forward and inward. In *epiphyseal separation* the line of fracture is at a lower level, about the adductor tubercle, is transverse, the crepitus is soft or cartilaginous, the patients are young, and the epiphysis can usually be felt displaced forward and resting on the front of the femur. *Intercondylar* or T-shaped fracture is recognized by the great swelling and broadening of the joint, by crepitus, and by abnormal mobility, each condyle moving separately from its fellow and from the shaft. Fracture of *either condyle* separately is recognized by the usual symptoms.

Complications.—Fractures of the femur are always serious injuries, especially if compound or occurring in old persons. Fat embolism, osteomyelitis, tetanus, or non-union may result. Intracapsular fractures of the neck seldom recover with bony union. Dislocation of the hip may occur as a complication, and injury to the popliteal vessels and nerves. Union without shortening rarely, if ever, occurs; but if the shortening do not exceed one inch the function of the limb is not seriously impaired.

Treatment.—Fractures of the *neck* or of the *middle* of the *shaft*

may be treated in the straight position, but fractures of the *upper* and *lower thirds* of the *shaft* should always be treated with the limb flexed, this not only being most comfortable to the patient, but, on account of the tilting forward of the upper fragment in fractures of the upper third and of the tilting backward of the lower fragment

FIG. 159.—Skiagram of epiphyseal separation of the lower end of the femur in a girl eleven years old.

in fractures of the lower third, the limb in flexion is placed in the position most likely to bring the fragments into line with one another. Examine fractures of the *neck* of the femur with great care, to avoid breaking up impaction; if this exist, steady the limb with sand-bags, without extension. In old or feeble persons it is often inadvisable to use any form of apparatus except sand-bags. Special care is necessary to prevent the formation of bed-sores and to provide for the proper nutrition of the patient. Extension is secured when necessary by the use of Buck's extension, Hodgens's or N. R. Smith's splint, or the double inclined plane.

Buck's extension is applied as follows: Cut a strip of strong adhesive plaster from two to four inches wide and long enough to extend twice the distance from the middle of the thigh to six inches below

FIG. 160.—N. R. Smith's anterior splint.

the foot. Lay this strip on a table with the adhesive side up, place a block of wood five inches long and three inches wide, with a hole bored in the middle, on the centre of the strip, and cover by another strip of plaster of the same width as the first and long enough to extend a sufficient distance on each side to prevent the plaster from adhering to the malleoli. Shave and dry the leg and thigh, and apply the plaster smoothly, taking care that the two ends reach the same level. A roller bandage is then put on to hold the plaster in

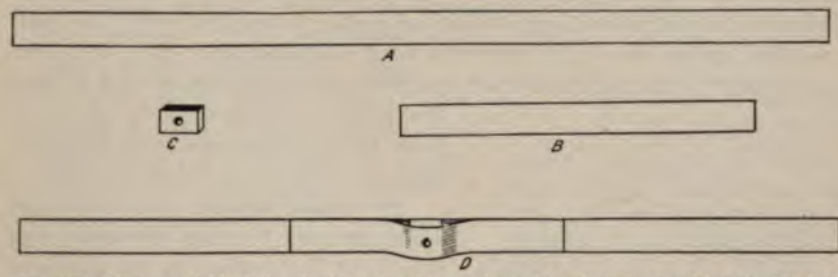

FIG. 161.—Plaster and block for Buck's extension: *A*, long strip of plaster to which the block *C* is held by means of a short strip *B*, as shown at *D*.

place. A small rope with a knot in the end is passed through the hole in the block, over a pulley fixed to the foot of the bed, and a weight of from five to sixty pounds is attached. Make counter-extension by raising the foot of the bed from four to six inches, placing a sand-bag between the legs of the patient. A Volkmann sliding rest may be placed under the leg and foot. In fracture of the *neck* the trochanter is kept from displacement backward and outward by a sand-bag placed beneath and to its outer side, and care should

be taken to prevent eversion of the foot and leg. Extension should be kept up for about a month, when the patient may be permitted to get up on crutches.

Hodgens's splint consists of two parallel iron bars, about as thick as an ordinary lead pencil, connected at the lower end by a straight bar

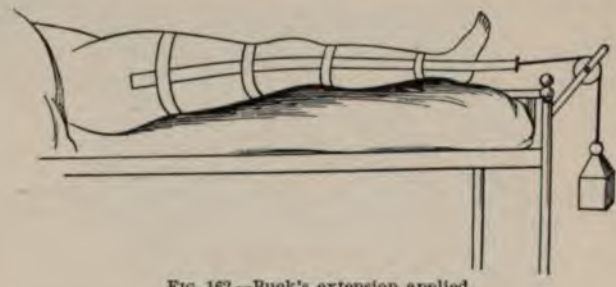

FIG. 162.—Buck's extension applied.

and at the upper end by a curved bar to make room for the thigh beneath. The bars should be long enough to extend from the groin to about six inches below the foot, slightly bent at the knee, and the space between them should be wide enough for the limb to pass without trouble. Strips of strong bandage are passed from one bar to the other, to support the limb when placed on them. Adhesive plaster, with a block and cord, is attached to the limb as in Buck's extension, the limb placed on the splint, and the cord from the block attached to the cross-piece below the foot. The splint with the limb is then raised from the bed by a cord attached near each end and suspended by a pulley four or five feet above the bed, placed so that the cord is inclined at an angle of from 10 to 20 degrees from the vertical, in order to produce traction.

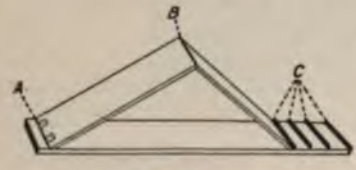

FIG. 163.—Double inclined plane: *A*, hinge; *B*, hinge where the two inclines meet; *C*, notches or strips to keep the end of the board from slipping.

The double inclined plane is placed with its apex beneath the knee, the thigh and leg resting on the inclined planes. Extension is made by the weight of the pelvis at one end while the leg and knee are fixed at the other. Extension may be increased by a weight and pulley in the line of the flexed thigh.

Senn recommends, for fractures of the *neck*, reduction by having the patient stand on the sound limb supported by assistants, the weight of the injured limb aiding in producing the necessary traction, while plaster of Paris is applied, enclosing the injured limb from the foot to the eighth rib and extending downward to the knee on the

sound side. An iron loop containing a screw is incorporated in the plaster so that by turning the screw pressure can be maintained on a pad placed over the trochanter to keep the fragments in apposition.

In children under ten years of age vertical suspension is a convenient method of treatment. Apply Buck's apparatus to one or both

FIG. 164.—Double inclined plane with extension.

legs and pass the cord through a pulley fixed above the bed, bringing up the limbs at right angles to the body.

In fractures of the *shaft*, before applying an apparatus reduce the fragments if possible, giving an anæsthetic if necessary. It is seldom possible to reduce a fracture of the femur without exposing the bone by operation. This may be done in suitable cases and the bones fastened with silver wire or drills.

In *compound fractures* no pains should be spared thoroughly to cleanse the wound and carefully to adjust and fix the fragments before closing it. In fractures involving the *knee-joint* apply Hodgens's splint or plaster of Paris from the foot to the hip with the leg slightly flexed. Some stiffness of the joint is apt to follow, but excellent results are sometimes obtained. The apparatus should be kept on two months (changing or removing it about once in two weeks), when there is usually enough union to permit the patient to walk with crutches, bearing no weight on the limb for another month. In children the time required for repair is somewhat less. The *ambulant* treatment of fractures of the femur is not recommended.

FRACTURE OF THE PATELLA is more frequent in males between twenty and fifty years of age, in the proportion of 5 to 1. The *causes* are usually muscular action, sometimes direct violence. The *varieties* are simple or compound, transverse, vertical, oblique, or stellate. When caused by muscular action the fracture is usually transverse and occurs at or below the middle of the bone.

Symptoms and Signs.—Separation of the fragments and abnormal mobility make the diagnosis easy. Ability to walk usually exists, but the power of extension is lost or impaired, depending on the extent to which the lateral fibrous expansions have given way. The separation of the fragments varies from a fraction of an inch to one or two inches. The swelling is due to hemorrhage and the excessive secretion of synovial fluid in the joint.

Complications may be inflammation of the joint, ankylosis, or ligamentous union.

Treatment.—There are two methods of treatment,—namely, by mechanical *apparatus* and by *operation.*

By Mechanical Apparatus.—Place the extremity on an inclined plane or a long splint, with the foot elevated about eighteen inches or more, in order to relax the quadriceps extensor. Press the fragments together and keep in position by compresses and figure-of-8

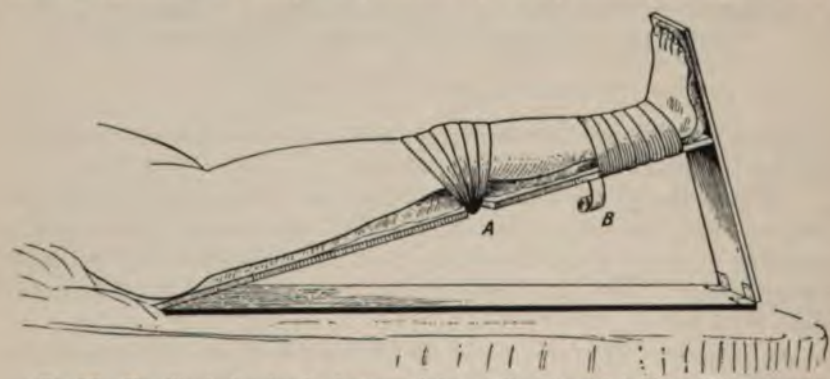

FIG. 165.—Hamilton's dressing for fracture of the patella: *A*, notch in the splint to prevent slipping of bandage over the patella; *B*, bandage which is carried from the foot to a point above the knee. (After Dennis.)

turns of a roller bandage placed so as to draw the upper fragment downward and the lower fragment upward; or use strips of adhesive plaster long enough to pass from above the patella to the splint below on either side. Use several strips, one slightly overlapping the other, and pass one across the front of the bone to prevent tilting of the fragments. Then apply a bandage from the foot half-way up the thigh. Renew the bandage every two or three days until all the swelling has subsided, and be careful to prevent excoriation.

Agnew's method consists in the use of a splint made of board about thirty inches long, five inches wide at the top and four at the lower end, with four lateral pegs. It is scooped out so as to be convex longitudinally and slightly concave from side to side. The splint, well padded, is applied to the posterior surface of the thigh and leg with

the lower end elevated. Strips of adhesive plaster are used, the ends passing from above the upper fragment to the peg on either side below the joint, and from below the lower fragment to the peg on either side above the joint. The strips are tightened by turning the pegs as the swelling subsides, thus keeping the fragments approximated.

Any form of apparatus or treatment should be continued for at least two months, when a plaster-of-Paris bandage may be applied from the foot to the middle of the thigh and the patient permitted to walk about for another month before attempting to use the knee-joint.

Operative Treatment.—The open method is superior to all others and is the only method usually followed by bony union. The operation should be done as soon as possible after the injury. Stimson makes a longitudinal incision in the median line, washes out the joint with hot sterile salt solution, unites the fragments by means of animal sutures passed through the periosteum and the torn lateral expansions of the quadriceps tendon, and closes the incision without drainage. The patient is kept in bed a week, when the outside stitches are removed and a light plaster cast applied and the patient permitted to get around on crutches. At the end of *three months* the joint may be used. The joint may be opened by a transverse or curved inoisicn and the fragments united with silver wire. The operation should not be undertaken except by one accustomed to doing operations of this kind and who has all the appointments necessary for insuring asepsis. Powers in 1898 reported 711 cases collected in which operation had been done, with the following results: 95 per cent. satisfactory, 3.6 per cent. ankylosis, and 1.4 per cent. death. Phelps in the same year reported 420 cases, with osseous union in 410, ankylosis in 21, and death in 3 cases—not due to the operation, 2 being from delirium tremens and 1 from carbolic acid poisoning. Stimson has operated in 70 cases by his method, with no deaths and a good result in every case.

Fractures of the Leg.—Fractures of the tibia and fibula are common, and may be divided into fractures of both bones, fracture of either bone singly, fractures of the upper extremity, shaft, and lower extremity, and epiphyseal separation.

Causes.—Fractures of the upper part are usually transverse and caused by *direct* violence, while those of the lower part are usually oblique and the result of *indirect* violence. Occasionally a fracture is the result of muscular action.

Fractures of the upper end may be *transverse*, *T-shaped*, *oblique*, or *vertical*, separating one or both condyles, or the epiphysis, or the

tubercle of the tibia. The *fibula* may also be fractured by sudden contraction of the biceps muscle.

Fractures of the Shafts.—Fractures of the shaft may occur at any point of either bone singly or of both simultaneously. The most common point of fracture of the tibia is about the junction of the middle and lower thirds, the line of fracture being oblique, passing from behind downward and forward. It is sometimes V-shaped, the open angle being usually formed by the lower fragment. When both bones are fractured at the same time the fibula is usually broken at a higher level than the tibia.

Fractures of the Lower End.—The most common is *Pott's fracture*, usually caused by forcible *eversion* and abduction of the foot, occasionally by forcible *inversion*. In a typical case the internal malleolus

FIG. 166.—Fracture at the lower fifth of the fibula, with the attendant deformity,—Pott's fracture.

FIG. 167.—Deformity after a badly-treated case of Pott's fracture.

is broken off at its base by the traction of the internal lateral ligament, a fragment of the external border of the articular surface of the tibia is detached by the tibiofibular ligament, and the fibula is fractured from two to four inches above the tip of the malleolus. In most cases only the fibula is fractured,—the internal lateral and tibiofibular ligaments rupturing without detaching their bony connections. At the same time the foot is displaced outward and usually backward.

Symptoms and Signs.—In fractures of the *upper end* of the *tibia* the usual signs—pain, crepitus, and abnormal mobility—are observed, and, if the fracture is oblique, shortening; also, if the knee-joint is involved, great swelling. If the upper end of the *fibula* be fractured, the upper fragment may be drawn slightly upward by the biceps. Fractures of the *shaft* of the tibia are detected without difficulty, on

FIG. 168.—Fracture of both bones of the leg. (Skiagram.)

FIG. 169.—Fracture of the tibia; fragments in place and wired. (Skiagram.)

FIG. 170.—Fracture of both bones of the leg; recovery in bad position. (Skiagram.)

account of the superficial position of the bone. When *both bones* are broken and the fracture is oblique, the lower end of the upper fragmen can be felt or seen under the skin in front above the ankle. It often penetrates the skin, making a compound fracture. Fracture of the *tibia alone*, if transverse, is not so easily detected, as it is held in position by the unbroken fibula acting as a splint. Fracture of the *fibula alone* above the upper fourth is even more difficult of detection, but the diagnosis may be made by the pain, local tenderness, and, possibly, *crepitus* and *abnormal mobility*. In fractures of the *lower end*, affecting either malleolus singly, the diagnosis is made by feeling the movable fragment. *Epiphyseal separation* may occur at either end of either bone, but it is most frequent in the lower end of the tibia. *Pott's fracture* is recognized by the outward displacement of the foot, the dropping backward of the heel, and the prominence of the internal malleolus, over which the skin is tightly stretched, sometimes giving way and allowing the end of the bone to protrude. On manipulation abnormal mobility, crepitus, and the detached tip of the malleolus may be felt.

Complications may be injury to the popliteal vessels or nerves, or ankylosis of the knee- or ankle-joints, with deformity of the latter.

Treatment.—In fractures of the *upper* ends and shafts reduction should be made by flexing the leg and then using extension, counter-extension, and manipulation. If the tension of the muscles prevent reduction in spite of anæsthesia, tenotomy of the tendo Achillis may be done. After reduction the limb may be enclosed in a plaster-of-Paris cast extending from the foot to a point well above the knee, with the leg in the position half-way between extension and right-angled flexion. Split the cast on each side as soon as it hardens. If there is much swelling, use the double inclined plane with fracture-box. When the knee-joint is involved and there is danger of ankylosis, the leg should be fixed nearly in a straight position—flexed about ten or fifteen degrees. Keep the foot nearly in a right-angled position, to avoid "pointed toe," and the ball of the toe should be in line with the inner border of the patella and the anterior iliac spine, or as near that position as comparison with the sound side shows to be correct. In *Pott's fracture* correct the displacement by flexing the leg, drawing the foot forward and pressing it inward to its normal position. Then apply plaster-of-Paris, holding the foot in a slightly inverted position while the plaster hardens; or use the Dupuytren splint. This is a board, four or five inches wide and long enough to extend from the knee to three inches below the foot. A pad is prepared for it, one inch thick above and three inches below, and long enough to reach from the knee to, but not below, the internal malleo-

lus. The leg is placed laterally, with the inner side next the padded splint, to which it is fixed by means of a roller bandage, the space below the pad permitting the foot to be held in a position of inversion. From three to six weeks are required for recovery. *Compound*

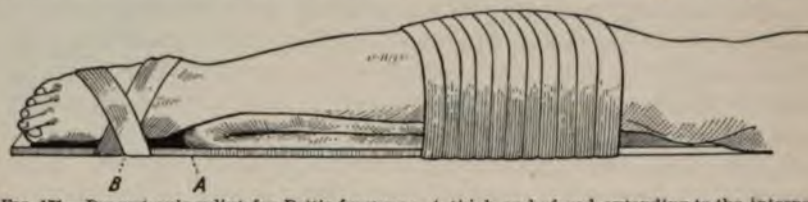

FIG. 171.—Dupuytren's splint for Pott's fracture: *A*, thick end of pad extending to the internal malleolus; *B*, bandage to produce slight inversion of foot.

fractures require the strictest antiseptic precautions to prevent infection. Should suppuration occur in the knee or ankle-joint, open freely on both sides and drain.

FRACTURE OF THE BONES OF THE FOOT.—The bones of the foot most frequently broken are the astragalus, the os calcis, and the phalanges.

FIG. 172.—Skiagram of fracture of the os calcis.

Etiology and Pathology.—Fracture of the *astragalus* is commonly the result of falls from a height, striking on the foot, producing a transverse, longitudinal, horizontal, or comminuted fracture. The most common point of fracture is through the neck. One or more of the fragments may be displaced. The *os calcis* may be fractured in the

manner, or by muscular action, the gastrocnemius pulling off a of bone at its insertion. *Fractures* of the *metatarsal* bones and *anges* are usually the result of direct force, as the dropping of a ht on the foot or the toe, and are often compound.

Symptoms and Signs.—In fracture of the *astragalus* there are pain, lling, inability to stand on the foot, and perhaps crepitus on manip- tion. The head or either fragment may be displaced and present

FIG. 173.—Compound fracture of the astragalus. (After Miller.)

under the skin. Fracture of the *os calcis* is indicated by the same symptoms, and, in addition, the arch of the foot is often destroyed, with flatness of the sole and shortening of the distance between the ends of the malleoli and the ground. If the line of fracture is *behind* the attachment of the lateral ligaments, the posterior fragment may be displaced upward. Fracture of the *metatarsal* bones and the *phalanges* can be recognized by the usual signs and symptoms.

Complications.—Fractures of the astragalus usually involve the ankle-joint, and may be followed by ankylosis.

Treatment.—In simple fractures of the *astragalus* and *os calcis*, if there is displacement reduce the fragments, giving an anæsthetic if necessary and making an incision if reduction is otherwise impossible. Then fix the foot and ankle from four to six weeks by means of a plaster-of-Paris cast. In *compound* fractures of the astragalus from direct violence the rule is to excise the bone, especially if there is comminution or if the fragments are displaced. Detachment of a portion of the os calcis by muscular action is treated by flexing the leg and extending the foot, then fixing the fragment in place by a compress and adhesive plaster, or by a nail or drill which can be removed after union takes place. Fractures of the *metatarsal* bones and *phalanges* are treated by reduction, with the application of splints of pasteboard, thin wood, or plaster of Paris. In *compound* fractures complete disinfection is of the highest importance to prevent infection and inflammation or tetanus.

CHAPTER III.

SURGERY OF THE JOINTS.

Diseases.

SYNOVITIS.

SYNOVITIS is inflammation limited to the synovial membrane. The varieties are *acute* and *chronic*.

Etiology.—It may be caused by wounds, contusions, sprains, cold, dampness, loose bodies in the joint, rheumatism, or pathogenic bacteria.

Pathology.—In *acute synovitis* the synovial membrane becomes vascular, congested, swollen, and œdematous, with increased effusion of synovial fluid, which may be normal in appearance, or watery, fibrinous, or purulent. The *chronic* form may result from acute synovitis, or it may be subacute or chronic from the beginning. The surrounding structures are more or less involved, resulting in arthritis. There are œdema, excess of fluid, and later thickening of the membrane and of the articular structures from the exudation of fibrin and the formation of fibrous tissue. The folds of the membrane are sometimes united by adhesions; villous growths may form on the fringes and project into the joint, and sometimes become detached and form "loose bodies."

Symptoms.—In the *acute form* there are pain in the joint, worse at night, tenderness on pressure, local elevation of temperature, tense swelling, fluctuation, floating of the patella, and mild constitutional symptoms. The position of the limb is always that which is most comfortable, usually one of slight flexion. In the *chronic form* there are thickening of the tissues and increase in the fluid in the joint; pain and tenderness are absent or slight; no local heat; swelling, fluctuation, and enormous accumulations of fluid (hydrops articuli, hydrarthrosis) are seen; impaired function; wasted muscles, and sometimes grating or crepitus. Arthritis may result.

Treatment.—In the *acute* form use hot or cold applications and secure complete rest by enveloping the limb in cotton and applying plaster or some other splint. In the *chronic* form try massage, small blisters frequently repeated, baths, electricity, ichthyol, mercurial ointment, or compression by means of an elastic bandage. In hy-

drops articuli the joint may be aspirated repeatedly, and if the fluid persist in returning an injection of tincture of iodine or a 3 to 5 per cent. carbolic acid solution may be used. The joint may be fixed by splints, but not long enough for adhesions to form. Treat any general disease, as rheumatism, gout, or syphilis, which may be a factor in the etiology.

ARTHRITIS.

Arthritis is inflammation of a joint as a whole, including all its structures. It may begin as a synovitis, but it is a more serious affection.

Varieties.—The forms of arthritis may be divided into two classes,—(A) the *infectious*, which includes those forms which are caused by, or which there is strong reason to believe are caused by, micro-organisms,—namely, (1) acute suppurative arthritis, (2) gonorrhœal arthritis, (3) arthritis of the exanthemata, and (4) tuberculous arthritis; (B) the *diathetic*, which includes (1) rheumatic, (2) gouty, (3) osteo-arthritis, (4) neuropathic, and (5) hysterical arthritis.

INFECTIOUS ARTHRITIS.—ACUTE SUPPURATIVE ARTHRITIS is caused by infection with pyogenic organisms, usually the staphylococcus or streptococcus, which gain entrance to the joint directly through an open wound; by the extension of a suppurative process, as in osteomyelitis; or by organisms contained in the blood current, as in pyæmia.

Pathology.—There is an acute form of inflammation with a tendency to rapid destruction of tissue. The synovial membrane, connective tissue, and ligaments soon become infiltrated with cells, which break down and form pus. The process extends to the cartilage and bones, which become disorganized, softened, and necrosis may result. Thrombosis of veins may occur, with detachment of infected emboli, which may be carried to distant organs and cause pyæmia or septicæmia.

The *symptoms* are chilly sensations, or a well-marked chill; high fever with a strong, full pulse; the joint is painful, tender, swollen, hot, œdematous, and fluctuation soon occurs; great prostration with symptoms of septicæmia—weak, rapid pulse, delirium, apathy, diarrhœa—may set in within a short time, with a quickly fatal result. In pyæmia several joints may be affected at the same time.

Prognosis.—Fibrous or bony ankylosis is apt to follow. Pyæmia or septicæmia makes the prognosis grave.

Treatment.—Open the joint without delay, evacuate pus, establish free drainage by rubber or glass tubes, place the limb in the best position for ankylosis, and irrigate with 1 to 5000 solution of bichloride daily. Necrosis of the bone may be followed by chronic

account of the superficial position of the bone. When *both bones* are broken and the fracture is oblique, the lower end of the upper fragmen can be felt or seen under the skin in front above the ankle. It often penetrates the skin, making a compound fracture. Fracture of the *tibia alone*, if transverse, is not so easily detected, as it is held in position by the unbroken fibula acting as a splint. Fracture of the *fibula alone* above the upper fourth is even more difficult of detection, but the diagnosis may be made by the pain, local tenderness, and, possibly, *crepitus* and *abnormal mobility*. In fractures of the *lower end*, affecting either malleolus singly, the diagnosis is made by feeling the movable fragment. *Epiphyseal separation* may occur at either end of either bone, but it is most frequent in the lower end of the tibia. *Pott's fracture* is recognized by the outward displacement of the foot, the dropping backward of the heel, and the prominence of the internal malleolus, over which the skin is tightly stretched, sometimes giving way and allowing the end of the bone to protrude. On manipulation abnormal mobility, crepitus, and the detached tip of the malleolus may be felt.

Complications may be injury to the popliteal vessels or nerves, or ankylosis of the knee- or ankle-joints, with deformity of the latter.

Treatment.—In fractures of the *upper* ends and shafts reduction should be made by flexing the leg and then using extension, counter-extension, and manipulation. If the tension of the muscles prevent reduction in spite of anæsthesia, tenotomy of the tendo Achillis may be done. After reduction the limb may be enclosed in a plaster-of-Paris cast extending from the foot to a point well above the knee, with the leg in the position half-way between extension and right-angled flexion. Split the cast on each side as soon as it hardens. If there is much swelling, use the double inclined plane with fracture-box. When the knee-joint is involved and there is danger of ankylosis, the leg should be fixed nearly in a straight position—flexed about ten or fifteen degrees. Keep the foot nearly in a right-angled position, to avoid "pointed toe," and the ball of the toe should be in line with the inner border of the patella and the anterior iliac spine, or as near that position as comparison with the sound side shows to be correct. In *Pott's fracture* correct the displacement by flexing the leg, drawing the foot forward and pressing it inward to its normal position. Then apply plaster-of-Paris, holding the foot in a slightly inverted position while the plaster hardens; or use the Dupuytren splint. This is a board, four or five inches wide and long enough to extend from the knee to three inches below the foot. A pad is prepared for it, one inch thick above and three inches below, and long enough to reach from the knee to, but not below, the internal malleo-

which plugs up a terminal blood-vessel, causing the formation of a pyramidal sequestrum and secondary invasion of the joint or of the surrounding soft tissues. The cancellous spaces are filled with embryonic tissue containing miliary tubercles which cause gradual softening and destruction of the bony tissue. When the *synovial* membrane is the seat of the disease it soon extends to the capsule, the bone, and the surrounding structures. Usually there is an excessive growth of granulation tissue which breaks down and then pus is formed. This, breaking through its boundaries, follows the lines of least resistance, dissects up the soft tissues, and points in various regions on the surface. The tuberculous granulation tissue causes gradual destruction, either by absorption or necrosis, so that the head and neck and even a part of the shaft of the femur may be destroyed, with considerable softening. The rim of the acetabulum may be destroyed, the head of the femur may escape from the acetabulum, and pathological dislocation on the dorsum ilii may result; or this may be due to destruction of the capsular ligament and contractions of the muscles.

Symptoms.—There are three stages,—(1) that in which the symptoms are due to irritation caused by the beginning activity of the bacilli; (2) that characterized by the fully developed inflammation, often called the *stage* of *lengthening*, on account of the apparent lengthening so characteristic of this stage; (3) the result of the destructive processes of the two preceding stages, called the *stage* of *shortening*.

(1) In the *first stage* the disease is apt to be overlooked or a wrong diagnosis made. Symptoms are: *Lameness* or *stiffness* in the morning before exercise; the patient tires easily and is indisposed to exertion. *Pain* is absent or slight, unless the disease begin in the osseous tissue. It is elicited by pressure on the trochanter or on the foot, pressing the head of the femur into the acetabulum, and is often referred to the inner side of the knee, owing to the relation and distribution of the obturator nerve. There is *rigidity* of the muscles about the joint, and the thigh may be slightly flexed in abduction. Some fulness of the joint in front of and behind the trochanter may be present in the synovial form.

(2) *Stage of Lengthening.*—The inflammatory changes are well established and the symptoms positive, as follows: A decided *limp*. *Abduction* and *eversion*, occasionally *adduction* of the limb exists. Apparent *lengthening* of the disabled limb, as the patient tilts his pelvis by sustaining his weight on the sound limb. Slight actual lengthening may be caused by effusion in the joint. Flattening of the buttock of the affected side. Obliteration of the gluteofemoral crease and deviation of the *rima natium* to the sound side. The adductors and flexors of the thigh are atrophied and rigid. Rigidity is

well shown by restricted movements and by *Sayre's test:* Place the patient, stripped, with his back on a table. It will then be found impossible to bring the lumbar spine and the popliteal space of the *affected side* in contact with the table at the same time. *Pain* is more

FIG. 176.—Position of spine in hip-joint disease when diseased limb is flexed.

marked, but not always present, is most severe at night, and is often "starting" in character, the patient awaking from slumber with a scream, due to sudden contraction of the muscles bringing the eroded

FIG. 177.—Arching of spine in coxalgia when diseased limb is extended.

surfaces of the femoral head and acetabulum together. Chills, elevation of temperature, and rapid pulse may be present.

(3) *The Stage of Shortening and of Abscesses.—Shortening* or *dislocation* may occur as a result of changes in the femur or acetabulum. There is great atrophy of the muscles, with adduction and flexion of the thigh, and Sayre's test is strongly marked. The *abscesses* usually form and point or open on the surface just below Poupart's ligament, near the knee, in the perineum, or they may perforate the acetabulum and open into the pelvic organs, the rectum, or the bladder. Fever sets in with evening exacerbations, sweats, and a general hectic condition. Abscesses occur in about half of the cases.

Diagnosis.—Vertebral disease may be excluded by the absence of spinal symptoms and by the presence of limp, pain, rigidity and deformity of the hip; *sacro-iliac disease*, by the patient being often under adult age, by the absence of pain on pressing the iliac bones against the sacrum, and by the presence of hip symptoms; *rheumatism*, by the absence of the characteristic deformity of hip disease and by only one joint being affected; *periarthritis*, by the absence of symptoms of an acute inflammatory process, with the early formation of abscess

superficial to the joint; and *congenital dislocation* of the hip, by the presence of inflammatory symptoms.

Prognosis.—Recovery may take place spontaneously, with ankylosis and deformity, or death may occur from invasion of the brain or other viscera, or from exhaustion from amyloid degeneration of the liver or kidneys. The prognosis is better in children than in adults. With early treatment the majority recover for the time being, but many of these perish from some form of tuberculosis before reaching middle age.

Treatment.—The treatment usually lasts for months or years, and requires inexhaustible patience and perseverance. The earlier it is begun the better for the patient. The great object to be obtained is absolute *rest* of the joint. This may be achieved by fixation, traction, or a combination of the two.

The Method by Traction.—Put the patient to bed and apply Buck's extension, with enough weight to make the patient comfortable. After six months let the patient get up and walk around on crutches, with a thick-soled shoe on the sound foot, bearing no weight on the affected limb.

FIG. 178.—Thomas's hip-splint.

FIG. 179.—Traction splint.

The Fixation Method.—If confinement cannot be borne, fix the joint with plaster extending from the ribs to the knee on the affected side,

or use a Thomas splint and let the patient walk with crutches. *The Method by Fixation and Traction.*—Some prefer a splint which combines both fixation and traction, of which there are quite a number, devised by Davis, Sayre, Taylor, Lovett, Wyeth, and Phelps. The principle is a bar of iron in two sections attached to the limb, permitting lengthening and extension of the limb by means of a key.

Operative Treatment.—Remove accumulations of fluid in the joint by aspiration. Treat abscesses by evacuation through a small incision and the injection of a ten per cent. mixture of iodoform in glycerin or vaseline, which is retained in the abscess cavity, repeated as often as the cavity refills. Balsam of Peru is sometimes used. In the *fungous* form use repeated injections of chloride of zinc, three to five per cent. solution; or, if there is much pain, the thermocautery may be thrust through the soft tissues and bone into the diseased area. If the disease persist in spite of treatment and the patient is losing ground, *erasion* or *excision* is indicated. *Excision* is more radical, but is likely to arrest the growth in length of the bone by removal of the epiphysis. In *erasion* the visibly diseased tissue is removed by the curette or knife. Pure carbolic acid should be poured over the affected parts and afterwards neutralized with alcohol.

Constitutional and Hygienic Treatment.—Give plenty of nourishing and easily digested food, and send the patient to a climate favorable to the cure of tuberculosis, such as is afforded by New Mexico, Arizona, Western Texas, and Southern California.

TUBERCULOSIS OF THE SACRO-ILIAC JOINT is usually seen in young adults from twenty to thirty-five years of age and may occur as a primary condition or secondarily to tuberculous affections of other parts. The *etiology* and *pathology* are similar to tuberculosis of other joints.

Symptoms.—The first symptoms are slight *stiffness*, *discomfort*, or *pain* after standing or walking for any length of time. Pain may be produced by coughing, sneezing, defecation, lying on the affected side, pressure over the joint, or by pressing the ilia against the sacrum, and may radiate along the sciatic, crural, and obturator nerves. The patient leans towards the sound side, bearing the weight of the body on that limb, the other being advanced and apparently lengthened from tilting of the pelvis. He limps in walking. Adduction is unusual. Pus may form and pass externally, pointing near the joint or the crest of the ilium; or internally into the pelvis, behind the rectum, into the ischiorectal fossa, opening into the rectum, or pointing near the anus; or it may follow the muscular planes and point in the vicinity of Poupart's ligament; or the sciatic nerve through the sciatic notch, pointing in the posterior region of the thigh.

The *diagnosis* is made from *neuralgia* of the joint, *lumbago*, and *sciatica* by the character of the pain, its long duration, and the signs of inflammation.

The *prognosis* is more unfavorable than in tuberculosis of the hip, especially if abscess form.

Treatment.—Secure absolute rest by confinement to bed and the use of a binder, or strips of adhesive plaster, or plaster of Paris applied to the pelvis, including the hip-joint of the affected side. In the early stages use the thermocautery for the relief of pain and arrest of the disease. Remove diseased bone by the use of the curette and chisel.

TUBERCULOSIS OF THE SHOULDER-JOINT.—The shoulder joint is less frequently affected with tuberculosis than the elbow and wrist.

FIG. 180.—Tuberculosis of the wrist.

Besides the ordinary form of the disease there is another, known as *caries sicca*, or *dry tuberculous arthritis*. It may affect other joints, but is most frequently observed in the shoulder, and in young adults. The bony structure is gradually destroyed without excessive formation of granulation tissue and without the formation of pus or other fluid. The *symptoms* are persistent pain, wasting of the muscles, and rigidity of the joint. On account of the atrophy of the muscles and absorption of the head of the humerus, the acromion process appears abnormally prominent, with a depression beneath it so that disloca-

tion may be suspected. The *treatment* consists in immobilizing the joint, and if after a reasonable trial this prove inefficient, excision should be performed.

DIATHETIC ARTHRITIS.—This division includes the varieties of arthritis which are the result of some constitutional condition and are not apparently due to specific organisms,—namely, rheumatic, gouty, osteo-arthritic (rheumatoid), neuropathic, and hysterical arthritis. Their treatment properly belongs to the physician, but the surgeon may be requested to remove fluid or correct deformity after ankylosis. The principles of treatment have been given in describing the forms of *infectious* arthritis.

NEURALGIA.

Neuralgia of the joints may be mistaken for hysterical joints, or the latter affection may assume the form of arthralgia. The *causes* given are diseases of the brain or spinal cord, malaria, neurasthenia, syphilis, or pressure on the nerve supplying the joint from tumors or products of inflammation.

Symptoms.—There is no evidence of inflammation, but the patient complains of severe burning or lancinating pain, intermittent in character, and it may appear at a certain hour of the day.

Treatment.—Try massage and electricity, or touch the skin over the joint lightly with the thermocautery. Break up adhesions, and if no local cause can be found, stretch the nerve, or excise it if small and unimportant. Give proper constitutional treatment.

ANKYLOSIS.

Ankylosis is restriction or loss of the motions of a joint as a result of changes in the structures which make up the articulation or of the surrounding structures. The varieties are *fibrous* (partial) and *bony* (complete).

Causes.—*Fibrous* ankylosis may result from traumatic, gonorrhœal, or rheumatic arthritis, which causes contraction of the ligaments; while *bony* ankylosis usually results from tuberculous, acute, suppurative, or osteo-arthritis, or any condition which destroys the articular cartilage and causes fusion of the bony surfaces. Severe injuries to the skin or contraction following burns of the skin and soft tissues may cause ankylosis.

Treatment. — The treatment consists in suddenly or gradually breaking up the adhesions, excision of the joint, and osteotomy. In *fibrous* ankylosis, break up the adhesions thoroughly under anæsthesia. Tendons which prevent extension may be tenotomized. Fix the limb in its new position and use passive motion once a week as

long as necessary. In *slight* cases the ankylosis may be gradually broken up by means of a weight extension, or massage and passive motion. In *bony* ankylosis of the shoulder or elbow, excision often gives a good movable joint. In the hip, knee, and ankle movable joints are not often obtained, but a vicious angle may be changed to a useful one—forcibly or by excision.

Dangers.—Attempts to break up ankylosis may cause rupture of the main blood-vessels, especially of the knee- or shoulder-joint, requiring amputation on account of gangrene; laceration of an important nerve, as the popliteal; the bone may be fractured; the fascia or skin may be extensively lacerated; or from the liberation of pathogenic organisms the inflammatory process to which the ankylosis is due may be excited anew. Ankylosis in children is frequently followed by arrested growth of the bone in length.

LOOSE BODIES IN JOINTS.

Loose bodies, from the size of a pea to a walnut, composed of fibrous, bony, or cartilaginous tissue, are sometimes found in the larger joints, especially the knee and elbow, about 90 per cent. of the cases occurring in the knee-joint.

Etiology.—The predisposing cause is arthritis, the bodies originating from the synovial membrane, fibrinous deposits, organized blood clots, as detached osteophytes in osteo-arthritis, or from portions of bone or cartilage broken off by injury.

The *symptoms* are weakness and fulness about the joint, and the patient may have observed the bodies in the neighborhood of the patella. Attacks of intense pain of a nauseating character, possibly with fainting, and locking or fixation of the joint in flexion may come on at any time, from the body getting caught between the bones. Synovitis may follow, and the condition may last two or three days, suddenly disappearing when the loose body is released.

Treatment.—An attack of locking may be relieved by forcibly flexing or extending the limb, giving an anæsthetic if necessary, and thus liberating the loose body. A knee-brace may be worn, but the bodies should be removed as soon as practicable. Under aseptic precautions, locate the body and hold it between the fingers or by means of a needle until an incision is made, the synovial membrane opened, and the body pressed out, or removed by means of forceps. Close the wound, uniting the capsule and synovial membrane with buried catgut and the skin with silkworm-gut suture, and immobilize the knee for about two weeks.

DISPLACEMENT OF THE SEMILUNAR CARTILAGES OF THE KNEE is a condition caused by the slipping or displacement of one of the

FIG. 181.—Bony ankylosis of five years' standing. (International Clinics.)

FIG. 182.—Bony ankylosis of twelve years' duration. Marked atrophy of muscles and limb. (International Clinics.)

semilunar fibrocartilages attached to the top of the head of the tibia so that it becomes wedged between the articular surfaces. It may be *caused* by chronic arthritis producing general relaxation of the joint, or traumatism by which the coronary ligament is ruptured. The direction of displacement may be inward, backward, forward, or the cartilage may be rolled on itself. The *symptoms* closely resemble those caused by the presence of loose bodies in the joint, including locking of the knee. The *distinction* may be made by feeling a depression in the normal position of the cartilage as compared with the sound side, and there will be no history of freely floating bodies having been observed by the patient.

The *treatment* is the same as for loose bodies, including excision of the loose cartilage. Expose the cartilage by a transverse incision along the upper end of the tibia, replace and attach its outer circumference to the periosteum of the tibia by animal sutures, or, if curled up and distorted, excise it.

Injuries of Joints.

SPRAINS.

A *sprain* is a contusion, stretching, or laceration of the synovial membrane and ligaments of a joint, caused by a sudden wrench or twist—often a dislocation with immediate spontaneous reduction.

Pathology.—The mechanism of a sprain is similar to that of a dislocation, the difference being that the articular surfaces are not sufficiently displaced to remain in the abnormal position. It occurs most frequently in the ankle or wrist or in a joint previously sprained. There may be only a stretching of the ligaments, with contusion or laceration of the synovial membrane, or severe injury with rupture or detachment of a ligament, laceration of nerves or blood-vessels with hemorrhage into the joint or the surrounding tissues, or displacement of adjacent tendons. A *sprain-fracture* is a sprain with fracture of the articular bony surfaces or the detachment of a ligament or tendon with a scale of bone.

The *symptoms* are severe pain and sometimes fainting; *swelling* follows, from increase of synovial fluid (great swelling occurring rapidly is probably due to hemorrhage), and ecchymosis of the skin; in the ankle the tendon of the peroneus brevis is sometimes displaced from its groove in the external malleolus.

Prognosis.—Ankylosis may follow hemorrhage into the joint or fracture of the articular surface, or permanent weakness result from rupture of ligaments or displacement of tendons.

Treatment.—In *mild* cases strap the ankle with strips of adhesive

plaster extending from the foot to the leg, or apply a thin rubber bandage from the foot upward, to support the ankle-joint and promote absorption of the effusion by compression, and let the patient walk about. In *severe* sprains use anodyne or evaporating lotions, soak the foot and ankle in hot water for several minutes, and as soon as practicable place the ankle at rest, enveloped in cotton and encased in a gypsum cast for one or three weeks, after which massage, electricity, and the rubber bandage or adhesive straps may be used.

WOUNDS OF JOINTS.

Wounds of joints are always serious injuries, the gravity depending on whether or not infectious material has been introduced, the amount of mechanical injury to the parts, and the anatomical peculiarity of the joint. Gunshot wounds and wounds of the hip- and knee-joint are particularly dangerous. Clean incised or punctured wounds, properly treated, are rarely followed by serious results.

The *symptoms* are often obvious. In others opening of the joint is indicated by the escape of synovial fluid (do not be misled by that which comes from a bursa or tendon sheath) and the careful use of the probe. Doubtful cases should be treated as wounds of the joint.

Treatment.—If small and probably not infected, close the wound, dress antiseptically, and keep the limb quiet until healing takes place. If probably infected, enlarge the wound if necessary, irrigate the joint with warm salt solution or bichloride solution 1 to 5000, and close with or without drainage, as may seem best. In severe or extensive wounds provide thorough drainage. Suppuration requires free opening, irrigation, and perfect drainage.

DISLOCATIONS.

GENERAL CONSIDERATIONS.—A *dislocation* or *luxation* is a complete or partial separation from one another of the articular surfaces of the bones which form a joint so that they remain in a new and abnormal position. Dislocations are less frequent than fractures in the proportion of one to ten. A *partial dislocation*, or *subluxation*, is one in which some portions of the articular surfaces of the bones still remain in contact, except the ball-and-socket joints, in which the dislocation is complete when the centre of the head of the bone is outside the rim of the socket, though the edges may still remain in contact. A *diastasis* is a form of dislocation of joints having little or no motion, as the symphysis pubis or the cranial sutures. The direction of dislocation refers to the movement of the distal member of the joint, except dislocation of the outer end of the clavicle.

STIMSON'S TABLE OF FOUR HUNDRED AND SEVENTY-FOUR DISLOCATIONS AT THE HUDSON STREET HOSPITAL AND DISPENSARY, 1894–1897.

Hip, dorsal	5	Lower extremity, 19,—4 per cent.
thyroid	1	
Knee	5	
Patella, outward	2	
Head of fibula	1	
Ankle	1	
Astragalus	3	
Metatarsus	1	
Clavicle, outer end	21	Upper extremity, 419,—88.39 per cent.
sternal end	3	
Shoulder	178	
Elbow	41	
Head of radius[1]	10	
Ulna, upper end[1]	6	
lower end	1	
Carpus	2	
trapezium	1	
semilunar	1	
Metacarpus	28	
Metacarpophalangeal and phalangeal	127	
Lower jaw	33	Head and trunk, 36,—7.59 per cent.
Vertebræ	3	
Total	474	

Varieties.—As in fractures, all dislocations may be classified as *simple* or *compound*. The subdivisions are: *Complete* and *incomplete* (already described); *complicated*, when a serious injury, as a fracture or laceration, coexists; *traumatic*, as a result of violence (this includes the large majority of dislocations); *single*, when only one joint is affected; *multiple*, when two or more joints are dislocated at the same time, as a shoulder and a hip; *double*, when corresponding joints on both sides of the body are dislocated, as both shoulders; *total*, when both ends of a long bone, as the clavicle, or a small bone, as the carpus, are dislocated; *unilateral*, when one joint of a bone having an articulation on each side of the body, as of the lower jaw or the vertebra, is dislocated; *bilateral*, when both joints of such a bone are dislocated; *pathological* or *spontaneous*, when the dislocation results from changes due to disease; *recent*, before marked changes in the direction of repair have taken place; *old*, in which changes have occurred which may seriously interfere with the reduction of the dis-

[1] Including cases with associate fracture.

placement; *habitual*, in which the dislocation frequently recurs on account of the relaxed condition of the ligaments; *voluntary*, when the patient can produce it at will; and *congenital*, in which the dislocation occurs in utero, probably as the result of defective development.

Causes.—Predisposing causes are: The *situation* of the joint, the upper extremity furnishing four-fifths of all cases; the *form* of joint,—other things being equal, ball-and-socket joints are most liable to dislocation; *sex*,—dislocations are three times more frequent in males than in females, except of the lower jaw, which is more common in females; *age*,—most dislocations occur between the ages of twenty and forty; *occupation*,—dislocations are frequent in persons exposed to injury; *muscular development*,—dislocations are most often seen in persons of good muscular development, because of their greater exposure; *diseases* of the joints, as chronic arthritis, which weakens the ligaments. The *exciting causes* are mechanical violence, direct or indirect, and muscular action, as in fractures.

Pathology.—The ligaments, blood-vessels, nerves, and muscles are stretched or torn; the cartilages are contused or chipped off. In *compound* dislocations the soft tissues are extensively injured and such injuries are usually more serious than compound fractures. If promptly reduced the rent in the capsule closes, the other tissues are repaired, and the joint is soon restored, nearly or quite, to its normal condition. If not reduced, changes take place in which the bony prominences are absorbed, while the cavities are filled up and effaced. The pressure of the head of the bone often results in the formation of a new joint lined by flat cells which secrete a fluid resembling the synovial. Adjacent vessels and nerves often become imbedded in the newly-formed tissue, and the muscles shorten; hence the danger in breaking up these adhesions.

The symptoms and signs are divided into—

Subjective.—Pain, more or less severe, perhaps nauseating, and *loss of function*, usually complete.

Objective.—Deformity, the *shape* of the joint being always changed, sometimes to such a degree as to be diagnostic. The *pathognomonic* symptom is the recognition of the end of the bone in an abnormal position. *Immobility*, more or less marked unless there is extensive laceration of the ligaments. *Change in length of the limb*,—measured between joints shortening exists usually, but in certain positions there may be lengthening. *Change in the direction of the limb* is often marked. *Crepitus*, soft in character, may be felt, especially in old dislocations. *Swelling and ecchymosis.*

Complications may be fracture of the bone involved, or injury to important blood-vessels and nerves or to internal organs.

Treatment.—A dislocation should be reduced as soon as practicable, unless there is some important contraindication,—as shock, threatening the patient's life. There are three methods used in making reduction: *Manipulation*, the preferable method when practicable, is the process by which the limb is placed in position to relax those muscles whose contraction prevents reduction, and by certain movements—making use of the attachment of ligaments and muscles as fulcra—the head of the bone is induced to retrace the route it took when it escaped from the socket. *Extension and counterextension with manipulation* can be made by means of a towel or sheet folded and placed about the patient's body or limb and held by an assistant, another assistant or the surgeon taking hold of the limb and making extension while the surgeon manipulates the joint. *The Method by Operation.*—If the first two methods fail after thorough trial with the aid of an anæsthetic, expose the joint by incision and reduce.

Obstacles to reduction may be the intervention of soft tissues, a small tear in the capsular ligament, changes which result from old dislocations, and the coexistence of fracture of the shaft of the bone.

SPECIAL DISLOCATIONS.

COMPOUND DISLOCATIONS are more frequently seen in hinge than in ball-and-socket joints, and require *special treatment.* As a rule, the treatment should be *conservative.* Always make an attempt to save the joint unless it is evident from the nature of the injury that this cannot be done. Irrigate with a 1 to 5000 solution of bichloride, then with sterile water, and if the wound is small close it and immobilize the joint. In the large joints, as the knee or ankle, provide drainage for at least three days. If the ends of the bones are comminuted or crushed, perform resection. *Secondary excision* may be necessary on account of suppurative arthritis. *Amputation.*—If the main blood-vessels are injured with extensive destruction of the soft parts or comminution of the bones, primary amputation is advisable, especially in dislocations of the knee. If the blood-vessels are injured with slight laceration of the soft parts without damage to the bones, an attempt may be made to save the limb by surrounding it with cotton, keeping it warm, and waiting a few days to see if collateral circulation will be established. On the appearance of the first symptoms of gangrene amputate above the knee.

CONGENITAL DISLOCATIONS occur *in utero*, and are to be distinguished from those which may be produced at the time of birth. The hip, shoulder, or knee may be affected, and the dislocation may be single or double. It is more frequent in females, and about 90 per cent. of the cases occur in the hip.

Congenital dislocation of the hip is sometimes hereditary, and is probably due to defective development of the acetabulum. Other causes given are changes due to rickets, or the contraction of certain muscles whose opponents have been paralyzed.

FIG. 183.—Double congenital dislocation of the hip.

Symptoms.—A *peculiar waddling gait* when the child begins to walk; if both sides are affected, with tilting of the pelvis and a compensatory lordosis; *limping*, in single dislocation; and shortening of the thigh, with the trochanter above Nélaton's line.

The *diagnosis* is made from hip disease by the history and the absence of signs of inflammation.

The *treatment* is *palliative* or *curative*. *Palliative* treatment consists in the use of corsets or pelvic belts made of leather, gypsum, or other suitable material used to fix the pelvis and support the trochanters. The *curative* treatment, evolved principally through the labors of Hoffa and Lorenz, may be *bloodless* or by *incision*.

The *bloodless method* is best suited to children under seven years of age. It consists of three steps.

1. Apply Buck's extension and stretch the muscles and ligaments until the head of the bone is brought down nearly or quite to the acetabulum. This step may be omitted and the second step immediately proceeded with.

2. Thoroughly break up all adhesions about the head of the femur and stretch the shortened muscles by extreme abduction, adduction, flexion, extension, and rotation; then flex the thigh on the pelvis, bringing the head of the femur behind the acetabulum, and by slight inward rotation and abduction to an angle of 90 degrees, if necessary, assisted by manipulation, force the head into the socket.

3. With the thigh well abducted, extended, and rotated slightly outward, apply a gypsum cast, including the pelvis and thigh, and keep on for three months, when the abduction may be somewhat reduced and a new cast applied. The patient is permitted to walk within a few days after the application of the first cast.

The *method by incision* is used if the former fail or seem inadvisable.

The patient should not be over ten years of age. Open the joint by an incision along the outer border of the tensor vaginæ femoris, crossing the femur a short distance below the trochanter and exposing the rectus muscle. Draw the rectus towards the front and the gluteus medius towards the back, expose and open the capsule of the joint, and free the head and neck of the femur. Clean or scoop out the old acetabulum, reduce the head of the femur by trimming if necessary, and reduce the dislocation by the usual methods; close the capsule and other tissues with sutures and apply a gypsum cast including the entire extremity and pelvis, with the thigh abducted and slightly flexed. A window may be cut over the wound for examination. The plaster is to be kept on at least four weeks and then renewed, and the child may be permitted to walk at the end of two months.

Of 234 patients operated on by Lorenz, Hoffa, and Delanglode 12 died and there were only 19 unsatisfactory recoveries, and 135 cases collected by Schanz[1] gave 109 excellent results with 7 deaths and 14 unsatisfactory recoveries.

DISLOCATIONS OF THE LOWER JAW may be unilateral or bilateral and the condyles may be displaced forward, outward, backward, or upward. Unless there is a fracture the direction of displacement is always forward.

Causes.—Dislocations *backward* or *upward* usually result from a blow on the chin, driving the condyles backward, fracturing the tympanic plate into the external auditory meatus; or upward, breaking the roof of the glenoid fossa into the cavity of the skull. Occasionally with fracture of the lower jaw a condyle may be displaced *outward* and above the root of the zygoma. The usual displacement is *forward*, and occurs most frequently during middle life in women, in the proportion of three or four to one. The most common *cause* is muscular action, as in yawning, laughing, scolding, vomiting; it may follow a blow on the jaw, or be caused by endeavoring to extract a tooth. The condyles glide forward beyond the articular eminences, stretching or rupturing the capsular ligament and the attachment of the meniscus. An obstacle to reduction is tension of the external lateral ligaments (Stimson), or occasionally the coronoid process catching beneath the malar bone.

Subluxation is indicated by sudden immobility of the jaw caused by slipping of the interarticular cartilages behind the condyles.

Symptoms and Signs.—In *bilateral* dislocation the mouth is open, the teeth are separated and cannot be closed, the lower jaw is advanced in front of the upper, the temporal and masseter muscles

[1] Zeitschrift für Orth. Ch., Band IV., Heft 2, p. 207.

stand out rigidly, the condyles are felt projecting in front of the articular eminences, and a depression can be felt in the glenoid cavities. In the *unilateral* form the symptoms are less marked, the mouth is not so widely open, and the chin points towards the sound side.

Complications may be fracture of the jaw, of the base of the skull, or concussion of the brain.

Treatment.—The surgeon, standing in front of the patient, places the thumbs, protected by glove fingers, on the last lower molar teeth on each side with the tips of the fingers resting under the chin and body of the lower jaw. The mouth is opened a little wider, and at the same time *backward* instead of downward pressure is made by the thumbs against the teeth or base of the coronoid process, and the chin elevated. In the event of failure give an anæsthetic, when, with the muscles relaxed, success will usually be achieved. If it be still found impossible to replace the condyles, open the joints, replace the meniscus if displaced, fasten by sutures, or remove it from the articulation. A bandage should be worn about two weeks.

Habitual dislocation of the lower jaw may be treated by opening the joint and suturing the meniscus to the periosteum at the margin of articulation. *Old irreducible dislocations* may be treated by reduction through an open wound or by excision of the condyles.

Noisy movement of the lower jaw is a condition in which mastication is accompanied by a snapping sound in the articulations, audible to the patient and frequently to those around him. The *cause* is probably a relaxed condition of the ligaments, and the treatment is that for *habitual dislocations.*

Dislocations of the Clavicle.—Either end may be displaced, but the outer end more frequently, or both ends may be displaced simultaneously (total dislocation). Occasionally both clavicles have been displaced simultaneously (double dislocation). The *sternal end* of the clavicle may be dislocated in three directions,—in order of frequency as follows: *forward*, *backward*, and *upward*,—as a result of force which carries the outer end backward or downward, acting on the first rib as a fulcrum, or of a direct blow on the sternal end. The *acromial end* of the clavicle may be displaced *upward* (supra-acromial),—the most frequent dislocation of the clavicle, *downward* (subacromial), *downward* and *backward*, or *downward* and *forward* (subcoracoid) under the coracoid process.

Symptoms and Signs.—Sternal End.—In *forward* dislocation the inner end of the clavicle can be seen and felt on the front of the sternum, the clavicular origin of the sternocleidomastoid muscle is felt as a tense band, the head is inclined towards the affected side, the space between the acromion and the middle line, compared with the

sound side, is diminished, and there is pain which is increased by movement. In *backward* dislocation a *depression* is felt in the normal location of the end of the bone, which may be felt through the sternal notch behind the sternum, and pressure symptoms may be present, such as dyspnœa, dysphagia, and congestion of the face and neck, or absence of the radial pulse. The shoulder drops somewhat downward and inward. In *upward* dislocation the end of the clavicle can be seen and felt projecting above the manubrium in the episternal notch behind the sternal origin of the sternomastoid muscle. Pressure symptoms may be present. *Acromial End.*—The *general symptoms* of dislocation of the acromial end are as follows: Pain and inability to use the arm, shortening between the acromion and middle line, the clavicular origin of the trapezius muscle is strongly outlined, apparent lengthening of the arm from dropping of the shoulder and inclination of the head towards the affected side. The *upward* and *downward* varieties are easily recognized by finding the end of the bone. In the *subcoracoid* variety the end of the clavicle may be felt beneath the coracoid process or lodged in the axilla, and the coracoid and acromion processes are unnaturally prominent.

Complications may be *fracture* and *pressure* on the *trachea*, *œsophagus*, and *large blood-vessels* behind the sternum.

Treatment.—In any variety of dislocation of the clavicle reduce by drawing the shoulder of the affected side backward and outward while the end of the bone is pressed or pulled into place. *Sternal End.*—In the *forward* variety after reduction place a compress over the end of the bone and hold in place by means of a figure-of-8 bandage through both axillæ crossing over the compress. Bind the arm to the side and support the elbow by a broad bandage passed diagonally to the opposite shoulder. In the *upward* variety the end of the bone may be kept in position by a compress held in place by strips of adhesive plaster or by a figure-of-8 bandage passed from the elbow of the affected side to the axilla of the sound side, crossing over the dislocated joint. In the *backward* variety, if there is a tendency to recurrence of the displacement, a figure-of-8 bandage may be applied around both shoulders, crossing in the back, taking care not to interfere with the axillary circulation. A gypsum cast may be used if preferred. In rare cases it may be necessary in backward dislocation to operate for the reduction of the displacement. Keep the bandage on for six or eight weeks, but examine frequently to ascertain whether the dislocation has returned or not. *Acromial End.*—For retention after reduction of *upward* displacement Stimson's method is best. Place a compress over the outer end of the clavicle, then place the centre of a strip of adhesive plaster four feet long and

three inches wide beneath the elbow, carry one end up in front and the other behind, crossing over the compress and extending sufficiently far across the chest behind and in front to obtain firm attachments. Or use a figure-of-8 bandage from the elbow to the opposite axilla, crossing over the affected joint. Support the forearm by a

FIG. 184.—Upward dislocation of acromial end of the clavicle.

FIG. 185.—Stimson's dressing for upward dislocation of acromial end of the clavicle.

sling and bind the arm to the chest. In *downward* dislocation, after reduction, fix the arm in the Velpeau position or by circular turns of a bandage around the trunk and arm, with the forearm carried in a sling.

DISLOCATION OF THE SCAPULA is the slipping of the inferior angle of that bone from beneath the latissimus dorsi muscle. It may be *caused* by paralysis of the serratus magnus muscle from injury to the long thoracic nerve, or in children from lifting them by one arm.

Symptoms and signs are pain and disability of the arm and a wing-like projection of the lower angle of the scapula, especially when the arm is drawn forward.

Treatment.—Relax the latissimus dorsi by carrying the arm backward and attempt to replace the bone by manipulation. Failing in this, make an incision, correct the displacement, and suture the muscle to prevent recurrence.

DISLOCATIONS OF THE SHOULDER-JOINT.—The shoulder is more frequently dislocated than any other joint in the body and is variously estimated to form from 40 to 65 per cent. of all dislocations. It is most frequent in middle life and in males, being rare in the very young and the very old.

Varieties.—According to Stimson, following Flower, four principal divisions may be made as follows:

Anterior	Subcoracoid, very common. Intracoracoid, exceptional. Subclavicular.
Downward	Subglenoid, uncommon. Luxatio erecta, very rare. Subtricipital, doubtful.
Posterior	Subacromial, rare. Subspinous, very rare.
Upward	Supraglenoid, very rare.

The *regular* dislocations of the shoulder may be considered in the order of frequency—as, the subcoracoid, subglenoid, subclavicular, and subacromial, the others being considered as anomalous or irregular.

Subcoracoid dislocation is the most frequent variety, forming about 75 per cent. of dislocations of the shoulder. The *cause* may be direct force, driving the head of the humerus forward and inward; indirect force, as falls upon the hand or elbow; or muscular action. The head of the bone escapes through a rent in the lower and inner part of the capsule, where the opening of the biceps bursa begins, and lies under the coracoid process above or below the subscapularis muscle, the anatomical neck resting on the anterior lip of the glenoid cavity, the posterior part of the capsule being stretched across the glenoid fossa. The muscles of the greater tuberosity, especially the supraspinatus, may be torn from their attachments, and the long tendon of the biceps is often pulled out of its groove. If the head of the bone pass to the inner side of the coracoid process, it is called an *intracoracoid;* and if it pass still further inward, the head of the bone resting on the chest wall just below the clavicle, it is called a *subclavicular* dislocation.

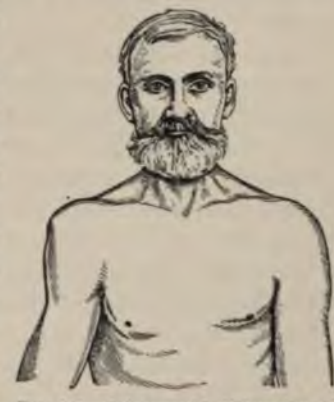

FIG. 186.—Subcoracoid dislocation of the shoulder. (After Helferich.)

Of the *downward dislocations* the *subglenoid* is the most common. It is caused by falls upon the hand or elbow when the arm is raised with the head of the bone pressing against the lower portion of the capsule; sometimes by muscular action. The capsule is torn below,

and the head of the bone escapes below or through the subscapularis muscle and rests upon the border of the scapula in front of the long head of the triceps muscle.

Luxatio erecta is a very rare form of exaggerated downward dislocation in which the arm is held vertically so that the forearm rests on the top of the head. *Subtricipital dislocation* is a downward form of dislocation in which the head of the bone is supposed to be displaced downward and then upward and backward behind and above the long head of the triceps muscle.

Posterior dislocations include the *subacromial* and the *subspinous*. They are caused by direct force applied to the front of the shoulder or indirectly through the elbow. The capsule is torn at the posterior part, and the head of the bone rests on the posterior edge of the glenoid cavity just below the posterior angle of the acromion (*subacromial* variety). If the head of the bone is carried still further backward, lying below the spinous process between the teres minor and the infraspinatus muscles, it is called a *subspinous* dislocation.

Upward or supraglenoid dislocation is very rare. It is caused by a fall upon the elbow or a blow on the acromion. The head of the humerus lies above the glenoid cavity in the interval between the acromion and coracoid processes, in front of the outer end of the clavicle.

Symptoms and Signs.—The symptoms and signs common to most dislocations of the shoulder are as follows: 1, pain; 2, restricted movements of the joint; 3, rigidity of surrounding muscles; 4, flattening of the shoulder; 5, prominence of the acromion process; 6, depression below the acromion; 7, the head of the bone may be felt in an abnormal position; 8, obliteration of the infraclavicular fossa; 9, the anterior axillary fold is less prominent; 10, flexion of the forearm to relax the biceps, and the elbow is usually supported by the other hand; 11, inclination of the head to the affected side; 12, shortening between the acromion and external condyle if measured with the arm extended; 13, change in the direction of the axis of the humerus; 14, Hamilton's sign—a straight-edged ruler can be made to touch the acromion process and external condyle of the humerus at the same time, except in upward dislocation; 15, Calloway's sign—the circumference of the joint is increased about two inches; 16, Dugas's sign—with the hand on the opposite shoulder the elbow cannot be brought into contact with the chest. This holds where the head of the bone is in contact with the chest wall, on the principle that a straight line (the humerus) tangent to a circle (the thorax) can only touch at one point.

The *diagnosis* is made chiefly by the *absence* of the head from the

glenoid cavity and finding it elsewhere, the *restricted motion*, and the deviation of the *axis* of the humerus. *Fractures* of the upper end of the humerus or of the neck of the scapula are recognized by crepitus and increased mobility, and, unless complicated by dislocation, the head of the bone is in the glenoid cavity; *paralysis* of the *deltoid*, by increased mobility and inability to raise the arm at right angles to the trunk. The varieties of shoulder dislocation may be distinguished by the differences presented in Pick's table:

Dislocation.	Axis of Arm.	Length (Arm nearly Parallel with the Body).	Head of Bone.
Subcoracoid	Elbow points backward and is slightly abducted.	Very slight lengthening.	Not easily felt; if so, in the upper and inner part of the axilla.
Subglenoid	Elbow points slightly backward and is abducted.	Considerable lengthening.	Easily felt in the axilla.
Subclavicular ...	Elbow points backward and outward.	Shortening.	Easily seen and felt below the clavicle.
Subspinous.....	Elbow points forward and is abducted.	Intermediate between glenoid and subcoracoid.	Can be felt and grasped below the spine of the scapula.

Complications may be fracture of the head, the anatomical or surgical neck, the tuberosities, the glenoid fossa, or the coracoid or acromion process; injury of the axillary vein or artery, the circumflex and subscapular vessels and nerves, and the cords from the brachial plexus—at the time of the accident, or later in attempts to reduce the dislocation.

Treatment.—Reduction may be effected by direct reposition, by extension and counterextension, by manipulation, or by a combination of these methods. Anæsthesia is often unnecessary.

Reduction of Anterior Dislocations.—By *direct reposition*, which is occasionally practicable, the surgeon simply presses the head of the bone into place with his fingers and thumbs.

Extension and Counterextension.—Place the patient on his back on a table. Pass a sheet around his body, under the axilla of the dislocated shoulder, and have an assistant hold the ends. The surgeon flexes the forearm on the arm to relax the biceps, and makes steady, not very forcible, traction downward, first in the line of the displacement, then gradually outward till the arm is at an angle of forty-five degrees, or a little more, with the chest, for from one to six minutes, possibly ten minutes, when the bone nearly always slips into place.

Kocher's method for *subcoracoid dislocation* depends on the efficiency of the untorn posterior portion of the capsular ligament. 1. Flex the elbow at right angles and press firmly against the patient's side. This tightens the posterior portion of the capsule. 2. With the elbow held in this position turn the forearm outward until it stands at right angles to the side of the body. This causes the head of the humerus to roll outward, winding itself on the unbroken portion of the capsule until it passes to the outer side of the coracoid process. Should the humerus fail to rotate outward, it may be aided by an assistant making traction outward on the neck of the bone or by traction downward in the long axis of the arm. 3. With the arm in external rotation, as described, move the elbow forward, upward, and slightly inward

FIG. 187.—Kocher's method of reducing dislocation of the shoulder: first and second steps.

FIG. 188.—Kocher's method: third step.

FIG. 189.—Kocher's method: fourth step.

until the arm is horizontal, when the head of the bone may slip into place. 4. If not, the fourth step consists in rotating the arm inward by carrying the hand to the opposite shoulder and lowering the elbow to the chest.

Extension and counterextension with the use of a fulcrum furnished by the surgeon's fist, foot, or knee are sometimes successful, but may

result in fracture of the ribs or injury to the vessels and nerves in the axilla.

Reduction of Downward Dislocations.—In *subglenoid* dislocation, first attempt to effect reduction by *direct reposition;* failing in this, by extension and counterextension with manipulation. Mothe draws the dislocated arm upward with one hand while he fixes the scapula with the other; and while an assistant presses the head of the bone upward towards the cavity the arm, still extended, is brought down to the side. *Luxatio erecta* is reduced by traction upward in the line of the uplifted arm until the head of the bone has been drawn into its socket. *Subtricipital dislocation* may be reduced in the same way.

Posterior dislocations can usually be reduced by direct pressure on the head of the bone from behind while traction is made upon the arm, either in a slightly forward or backward direction, with external or internal rotation, as may seem best.

Upward dislocation may be reduced by traction in the axis of the limb and extension of the arm while pressure is made on the head of the bone in the direction of the glenoid cavity.

All other methods failing to effect reduction, *open arthrotomy* is justifiable.

After the reduction of a dislocation fix the arm to the chest in the Velpeau position, or with the forearm in a sling, for three or four weeks, to permit of repair of the lacerated structures.

Dislocation of the Humerus with Fracture of the Surgical Neck.—The coexistence of fracture can be determined by the presence of an abnormal point of motion and crepitus. Treat such a case by attempting to reduce the dislocation by *direct reposition.* Failing in this, make an incision over the site of the fracture, avoiding the joint, if possible, and make traction by means of a hook inserted in a hole bored in the upper fragment (McBurney), or by a pair of lion-jawed forceps, and press the head into place. The dislocation reduced, the fracture is treated in the usual way. If the fracture is through the anatomical neck and reduction without operation impossible, the head of the bone should be excised.

Old Dislocations of the Humerus.—If the function of the new joint is good, do not interfere. Dislocations have been reduced after the lapse of several months, or even years. Kocher reduced by manipulation twenty-five out of twenty-eight old dislocations, three of them over four months old. Before attempting reduction, give preliminary treatment by massage and passive motion in order to break up adhesions and render the parts more pliable. Anæsthetize the patient and try the various methods of extension and manipulation, and if they fail, open the joint and reduce, or exise the head of

the bone. *Dangers* are fracture of the humerus or ribs, injury to the nerves, and rupture of the axillary vein or artery or their branches. Rupture of a blood-vessel would be indicated by a more or less rapidly developed swelling in the axilla and under the pectoral muscles, sometimes with absence of the radial pulse. If the artery is ruptured, there will be pulsation in the tumor. Probably the best treatment of such cases is by operation—double ligation and removal of the clot. Stimson reports forty-nine cases of injury to the axillary vessels caused by dislocation of the humerus or by attempts at reduction, with sixteen recoveries and thirty-two deaths.

DISLOCATIONS OF THE ELBOW are next to those of the shoulder in frequency, and are most common in young persons, probably 50 per cent. occurring in children under fifteen years of age.

Varieties.—Both bones of the forearm may be displaced together in the same direction, or each bone may be displaced in a different direction, or either may be displaced alone, the other remaining in place.

Dislocation of both bones may be *backward*, *forward*, *lateral*, and *divergent*.

Dislocations of the ulna alone are *backward*, *forward*, and *inward*.

Dislocations of the radius alone are *forward*, *outward*, *backward*, and *downward*.

Backward displacement of both bones is the most frequent dislocation of the elbow. It is usually *caused* by a fall upon the palm of the outstretched hand, producing hyperextension of the elbow and abduction, or by torsion of the forearm. The ligaments are torn, the coronoid process of the ulna, unless fractured, lodges in the olecranon fossa, while the head of the radius projects behind the external condyle.

Dislocation of both bones forward is a rare accident, unless the olecranon be fractured at the same time. The usual *cause* is a fall or blow on the olecranon while the forearm is flexed. The upper end of the olecranon rests against the under and anterior surface of the humerus, or passes up in front of it while the head of the radius is separated from the capitellum humeri. In fracture of the olecranon this process is found in place, while the head of the radius and broken end of the ulna pass forward to the anterior surface of the humerus.

Lateral dislocations, commonly incomplete, are caused by a fall upon the outstretched hand, or by force acting above and below the elbow at the same time and in opposite directions. In the *inward* variety (incomplete) the ulna rests upon the internal condyle and the head of the radius on the trochlear surface of the humerus; in the *external* variety (incomplete) the sigmoid notch rests against the external condyle, or capitellum humeri, while the head of the radius may

remain in contact with the outer margin of the radial surface of the humerus or be entirely external to the external condyle. In *complete external* dislocation the sigmoid cavity rests against the outer surface of the external condyle, or embraces the supinator ridge, the radius projecting still more externally.

Divergent dislocation includes two varieties—the *anteroposterior*, in which the ulna passes up behind and the radius in front of the humerus, and the *transverse*, in which the ulna passes to the inner and the radius to the outer side of the humerus. The *cause* is a fall upon the elbow or hand, probably producing abduction with laceration of the internal lateral ligament, followed by forcible pronation, the weight of the body driving the humerus between the bones.

Dislocation of the ulna alone may be *backward*, *inward*, or *forward*, being nearly always *backward*. The coronoid process slips into the olecranon fossa, while the head of the radius remains in its normal position, the orbicular ligament being usually uninjured.

FIG. 190.—Forward dislocation of the head of the radius.

Of dislocations of the radius alone forward displacement is the most frequent, in which the head of the radius rests above the capitellum humeri when the forearm is flexed. It is *caused* by falls upon the hand, producing exaggerated pronation, or by a blow on the back of

FIG. 191.—Backward dislocation of the head of the radius.

the joint. *Outward dislocation* of the head of the radius, except when accompanied by fracture of the ulna, is rare. The *cause* may be a fall on the hand or a blow on the elbow. *Backward dislocation* of the head of the radius is also rare. The cause is a fall upon the hand,

probably producing hyperextension and supination of the forearm. The orbicular ligament is usually torn, and the head of the bone passes beneath and behind the external condyle of the humerus. *Dislocation downward*, or *subluxation* of the *radius*, is usually seen in children under five years of age, and is a common accident. The *cause* is excessive traction, as by lifting the child by the hand or wrist, possibly with forced pronation. There is some confusion as to the pathology, but it is probable that the head of the radius is drawn below the upper border of the orbicular ligament, as this has been proved possible by traction and forcible adduction of the forearm. It is possible also that the radius is displaced so that its tuberosity catches behind the outer border of the ulna.

Symptoms and Signs.—In a normal elbow a straight line drawn from one condyle to the other across the back of the joint with the forearm in extension touches the upper end of the olecranon, which is slightly nearer the internal than the external condyle.

Dislocations of Both Bones.—In *backward dislocation* there are abnormal projection of the elbow backward, greater distance between the tip of the olecranon and the apex of the internal condyle than that on the sound side, shortening of the forearm, projection of the end of the humerus in front of the joint, and limited motion, unless there is unusual laceration of the ligaments. *Fracture above the condyles* can be excluded by the absence of a false point of motion, crepitus, and shortening of the humerus. In *forward dislocation* the forearm is lengthened, the olecranon is absent at the back of the humerus, the sigmoid cavity may be felt in front of the joint, and a space may be detected between the head of the radius and the capitellum humeri. In *lateral dislocation* the elbow-joint is widened and motion is limited. In the *outward* variety the head of the radius is felt outside of its normal position, while the internal condyle and the trochlear surface are abnormally prominent on the inner side. In the *complete outward* variety both bones are felt to the outer side of the articular surface of the humerus, and the forearm may be in extreme pronation with the sigmoid cavity embracing the outer border of the humerus. In the *inward* variety the sigmoid cavity is felt to the inner side of the trochlear surface, against which the head of the radius may rest while the external condyle and capitellum humeri are abnormally prominent. Instead of being *directly* inward or outward, the displacement is sometimes also backward with either variety of lateral dislocation. In *divergent dislocation*, in the *anteroposterior* variety, the olecranon is felt above its normal position behind the humerus while the head of the radius occupies a corresponding position in front. The forearm is shortened and extended or slightly flexed. In the

transverse variety the olecranon is felt to the inner side of the humerus, the head of the radius to the outer side, while the articular surface of the humerus can be felt projecting between the two. The forearm is semiflexed. *Dislocation of the ulna alone, backward*, is indicated by the abnormal projection of the olecranon behind while the head of the radius is found to occupy its normal position. The forearm is slightly flexed and pronated. *Dislocation of the Radius Alone.*—In *forward* dislocation there is inability to flex completely the forearm and the head of the radius is felt on the front of the humerus above the capitellum humeri. In *outward* and *backward* displacements the diagnosis is made by recognizing the head of the radius in its abnormal position. In the *downward* variety, or *subluxation*, the diagnosis is made by the history of the case and the following symptoms: The forearm is slightly flexed and pronated; neither complete flexion, extension, nor supination can be made without pain and resistance; pressure over the head of the radius causes pain, and sometimes a space can be felt between the head of the radius and the capitellum humeri.

Complications may be fracture, compound dislocation, displacement or injury of the ulnar nerve.

Treatment.—To reduce *backward dislocation* of both bones, or of the ulna alone, flex the forearm slightly, take hold of the elbow with both hands, with the fingers over the ends of the olecranon and radius, while the thumbs are superposed over the lower end of the front of the humerus. In this position press the humerus backward with the thumbs, and draw the olecranon and radius forward with the fingers until the coronoid process slips over the trochlear surface of the humerus. If this method fail under an anæsthetic, make *traction* on the forearm in complete extension, or even hyper-extension, until the coronoid process is released from the olecranon fossa; then employ flexion, aided possibly by downward pressure on the olecranon. In *anterior* dislocation of both bones or of the olecranon alone, flex the forearm over the knee, if necessary, pressing or pulling the upper end of the forearm downward and backward. *Lateral* dislocations can often be reduced by *direct reposition*, if needful extending or hyperextending the forearm. The reduction of *divergent* dislocations seems to have been accomplished with considerable difficulty in some cases by traction and manipulation. In *forward* dislocation of the head of the radius, flex the forearm to relax the biceps muscle, then press the head of the bone into its place in the lesser sigmoid cavity and on the capitellum humeri, and fix the forearm in flexion. In *outward* dislocation of the head of the radius, press the head downward and inward while making extension and counter-

extension, with the elbow moderately flexed. In *backward* dislocation, flex the forearm, then, while an assistant holds the arm near the elbow, make extension of the forearm from the wrist, with supination, and press the head of the radius forward; or make traction in full extension while the forearm is adducted. Dislocation *downward*, or *subluxation*, is easily reduced by forced supination while the forearm is flexed at a right angle.

DISLOCATION OF THE INFERIOR RADIO-ULNAR ARTICULATION.—The lower end of the ulna may be dislocated *forward* by direct violence acting in opposite directions on the lower end of the ulna and radius, or by exaggerated supination, the head of the ulna slipping out of the sigmoid cavity of the radius and resting on its anterior surface; or *backward* by direct violence or muscular action, as by wringing clothes, or by exaggerated pronation the head of the ulna passes behind and rests on the posterior surface of the radius.

Symptoms and Signs.—In both, the distance between the two styloid processes is diminished, and the variety is determined by the position of the lower end of the ulna.

Treatment.—Make reduction by direct pressure on the end of the ulna, aided by pronation or supination of the radius, according to circumstances. Then fix the forearm and wrist for two or three weeks.

DISLOCATIONS OF THE WRIST may be *forward* or *backward*, as a result of direct violence, or a fall striking on the back or the palm of the hand. One or all four of the ligaments may be ruptured, and not infrequently the anterior or posterior lip, or the styloid process of the radius may be fractured. In the *anterior* variety the carpal portion of the joint is displaced forward, and rests on the anterior surface of the radius and ulna. In the *posterior* variety this relation is reversed.

Symptoms and Signs.—The deformity resembles that of a Colles's fracture and the reversed Colles's fracture, but in *dislocation* the deformity is nearer the hand, is more abrupt, the hand and wrist are usually more flexed or extended and more rigid, and the styloid processes occupy their normal relation to one another.

Complications may be rupture of the ligaments and tendons, fracture of the radius, separation between the bones of the carpus, or the violence may be so great as to produce a compound dislocation. Reduction is usually easily effected by means of traction and pressure.

DISLOCATION OF THE CARPAL BONES may take place individually or at the mediocarpal articulation, forward or backward, but such accidents are extremely rare. The bones most frequently dislocated singly are the *semilunar*, the *scaphoid*, and the *pisiform*. Of 54

dislocations of carpal bones singly, 23 were of the *semilunar*, of which 22 were palmar; 7 of the *scaphoid;* 5 of the *semilunar* and *scaphoid* together; 5 of the *pisiform;* 4 each of the *trapezium* and *trapezoid;* 3 of the *unciform*, and 1 of the *os magnum* (William Hessert). The *treatment* consists in restoring the displaced bone to its normal position, or in excision.

CARPOMETACARPAL DISLOCATION.—The metacarpal bones may be dislocated from the carpus singly or altogether, or the inner four may be dislocated together. The metacarpal bone of the thumb is the one most frequently displaced, and the direction may be forward, backward, or outward. The four inner metacarpal bones have been displaced together, forward and backward. Reduction is accomplished by traction and pressure.

DISLOCATION OF THE METACARPOPHALANGEAL AND INTERPHALANGEAL ARTICULATIONS.—Dislocations of the metacarpophalangeal and of the interphalangeal articulations are common, especially the metacarpophalangeal joint of the *thumb*, which may be displaced *backward*, *forward*, or to the *inner side*. The backward dislocation is the usual one, and may be caused by exaggerated extension or flexion. It may be *incomplete*, *complete*, or *complex*. In the *incomplete* form the base of the first phalanx of the thumb passes backward, so that its articular surface rests against the posterior margin of the head of the metacarpal bone, the first phalanx of the thumb making an obtuse angle with the metacarpal bone, and can be produced by some persons at will by contraction of the extensor muscles. If the base of the phalanx is carried still farther back, so that it rests behind and above the articular surface of the metacarpal bone, a *complete* dislocation is produced, and the first phalanx stands at right angles, or nearly so, to the metacarpal bone, and the last phalanx is strongly flexed. The *complex* form is so from the accident, or is the result of attempts to reduce the complete displacement by traction on the thumb. The first phalanx has been turned forward from its right-angled position, and lies parallel with the metacarpal bone, and the torn edge of the anterior ligament is between them, closely embracing the metacarpal bone behind its head. (Stimson.)

FIG. 192.—Backward dislocation of the thumb.

Treatment.—Be careful not to flex the first phalanx of the thumb and produce a complex dislocation. *Keetley's method:* Anæsthetize the patient, flex the metacarpal bone into the palm of the hand, and hold it there in order to relax the flexor muscles. Then,

keeping the first phalanx of the thumb at right angles to the metacarpal bone, slide the base by strong pressure towards the head of the metacarpal bone until it reaches the proper position, and then flex. Should this method fail on account of the intervention of the anterior ligament or of the heads of the flexor brevis pollicis, open arthrotomy should be performed and reduction effected. Under no circumstances should strong traction by means of apparatus be made on the thumb, as the last phalanx may be avulsed. Dennis figures in his "System of Surgery" the distal phalanges of three

FIG. 193.—Backward dislocation of the thumb, showing the relation of *A*, the head of the metacarpal bone, to *B*, the base of the first phalanx.

FIG. 194.—Method of reducing backward dislocation of the thumb, keeping the first phalanx at right angles to the metacarpal bone while the base of the first phalanx is pushed forward.

thumbs avulsed along with the long flexor tendon in attempts to reduce dislocation. *Forward dislocation* of the thumb is less common than *backward* dislocation, but may be caused in the same way and is reduced by traction and pressure. *Interphalangeal dislocations* may be backward, forward, or lateral, and are frequently compound. The *symptoms* are obvious, and *reduction* is effected by traction and pressure.

DISLOCATIONS OF THE PELVIS.—Dislocation or diastasis of the pubic or sacro-iliac joints seldom occurs without fracture, which has already been described. *Dislocation of the coccyx* may be forward, backward, or lateral, and is usually *caused* by direct violence. The

diagnosis is made by the pain and by examination with the finger in the rectum. The *treatment* consists in reducing the displacement by pressure, and if recurrence cannot be prevented and the pain and disability persist, the bone should be removed by excision.

DISLOCATIONS OF THE HIP occur most frequently during the active period of life, and may be *outward* (posterior) or *inward* (anterior). (Allis). These may be subdivided and their relative frequency given as follows: *Iliac* (above the tendon of the obturator internus), about 50 per cent.; *ischiatic* (below the tendon), 30 per cent.; thyroid (obturator), 11 per cent.; *pubic*, 7 per cent.; and certain anomalous displacements, 2 per cent. The relations to the hip-joint of the Y-ligament, of the obturator internus muscle, and of the sciatic nerves are important in connection with dislocation.

Causes.—The *outward* variety is usually caused by indirect violence acting on the outer side of the knee or foot, producing exaggerated adduction and inward rotation while the limb is flexed. The capsule is torn at its lower posterior portion, longitudinally or transversely, and the head of the femur rests on the bone just behind the acetabulum, below the obturator internus muscle. If the knee is lowered, the head of the bone rises and may pass above the tendon. *Inward* dislocation may be caused by a blow upon the back of the pelvis while the limb is flexed and abducted, or by exaggerated abduction. The capsule is torn on the inner and lower side, and the head of the bone rests on the obturator foramen or on the ramus of the pubes.

FIG. 195.—Deformity in outward or backward dislocation.

Symptoms and Signs.—In *outward* dislocation the limb is inverted, the toe touching the instep or ankle of the opposite foot, the heel is raised, the knee is slightly flexed and touches the upper margin of the other patella, the thigh is rotated inward and adducted, so that the axis prolonged downward would pass through the lower third of the other thigh. The fascia lata is relaxed (Allis's sign), shown by indenting the tissues between the trochanter and crest of the ilium. The limb is shortened from one to three inches, especially marked in the recumbent position on

FIG. 196.—Reduction of outward dislocation. (Bigelow.)

flexing the thighs. The trochanter major is above Nélaton's line. The hip looks flat and broad, and a depression may be felt over the acetabulum while the head of the femur may be felt in an abnormal position, and the joint is fixed by the rigidity of the muscles. Fracture is excluded by the absence of eversion of the limb, crepitus, and mobility.

Inward dislocation—thyroid—is indicated by the following symptoms and signs: The toe points downward and outward and the foot is slightly everted, the thigh is slightly abducted and cannot be adducted; the trochanter major is below Nélaton's line; the hip is flattened; the gluteal fold is lowered; a depression may be felt over the acetabulum and the head of the bone may be felt in its new position; the limb is usually slightly lengthened (one-half inch), but if strongly abducted it may be shortened; the body is bent forward and towards the affected side; and rigidity of the muscles is marked. In the recumbent position the knees cannot be drawn together. In the *pubic* variety the symptoms are about the same, except that the limb is shortened and the head of the bone can be felt on the pubis to the inner side of the femoral vessels.

Fig. 197.—Deformity in inward or thyroid dislocation of femur.

Fig. 198.—Reduction in inward or anterior dislocation. (Bigelow.)

Complications and obstacles to reduction may be fracture of the femur; a small rent in the capsular ligament; tension of the Y-ligament; the muscles, obturators, may embrace the neck of the bone; or the sciatic nerve may become looped around the neck of the bone.

Treatment.—The methods of Allis are considered safer and more likely to succeed in reducing dislocations of the hip than any of the older methods. Anæsthetize the patient and place him in the dorsal position on a firm mattress or table. Fix the pelvis, either by the hands of an assistant or by bandages crossing the pelvis and attached to screws on either side of the pelvis and near the perineum. To reduce an *outward* dislocation of the *right* hip, kneel by the side of the patient and place the left elbow under the patient's knee, at the same

time take hold of the ankle with the right hand. (1) Now rotate the femur inward by turning the ankle outward, and lift upward (skyward) with the left arm. (2) Produce external rotation by turning the ankle inward and bring the femur down in extension. With the thigh flexed at right angles the head of the femur lies just below the acetabulum and the Y-ligament is relaxed. Internal rotation frees the head of the bone so that it may be lifted over the rim of the acetabulum. Outward rotation changes the position of the head of the femur with reference to the acetabulum from a lateral to a direct position, while extension makes use of the Y-ligament as a fulcrum by means of which the head of the bone passes upward into the acetabulum as the knee is lowered. To reduce *inward* dislocations: (1) Flex (but not to a right angle) and abduct the femur. (2) Make traction downward and outward in the line of the femur. (3) Have an assistant fix the head of the bone by digital pressure on its inner side while the surgeon adducts the knee. By flexion and abduction the Y-ligament is relaxed and by traction the head of the bone is drawn from its position in the obturator foramen, or on the pubes, to the margin of the acetabulum. By means of adduction, aided by digital pressure on the head and the attachment of the Y-ligament, the head of the bone is made to pass outward into the acetabulum.

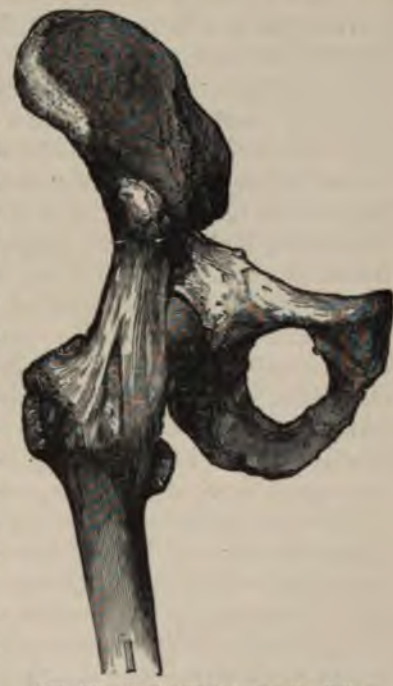

FIG. 199.—Hip-joint, showing the Y-ligament of Bigelow.

Hooking up of the sciatic nerve is indicated by inability to extend the thigh completely, or, if extension be made, the nerve may be felt as a tense cord in the popliteal space, and by pain and a springy motion imparted to the limb. In order to free the nerve Allis advises redislocation of the femur and its reduction with the leg flexed to relax the nerve. If this fail, expose the nerve by incision and free it.

The older methods for effecting reduction are as follows: For *outward* dislocation flex the leg on the thigh and the thigh on the pelvis, relaxing the Y-ligament and disengaging the head of the femur

probably producing hyperextension and supination of the forearm. The orbicular ligament is usually torn, and the head of the bone passes beneath and behind the external condyle of the humerus. *Dislocation downward*, or *subluxation* of the *radius*, is usually seen in children under five years of age, and is a common accident. The *cause* is excessive traction, as by lifting the child by the hand or wrist, possibly with forced pronation. There is some confusion as to the pathology, but it is probable that the head of the radius is drawn below the upper border of the orbicular ligament, as this has been proved possible by traction and forcible adduction of the forearm. It is possible also that the radius is displaced so that its tuberosity catches behind the outer border of the ulna.

Symptoms and Signs.—In a normal elbow a straight line drawn from one condyle to the other across the back of the joint with the forearm in extension touches the upper end of the olecranon, which is slightly nearer the internal than the external condyle.

Dislocations of Both Bones.—In *backward dislocation* there are abnormal projection of the elbow backward, greater distance between the tip of the olecranon and the apex of the internal condyle than that on the sound side, shortening of the forearm, projection of the end of the humerus in front of the joint, and limited motion, unless there is unusual laceration of the ligaments. *Fracture above the condyles* can be excluded by the absence of a false point of motion, crepitus, and shortening of the humerus. In *forward dislocation* the forearm is lengthened, the olecranon is absent at the back of the humerus, the sigmoid cavity may be felt in front of the joint, and a space may be detected between the head of the radius and the capitellum humeri. In *lateral dislocation* the elbow-joint is widened and motion is limited. In the *outward* variety the head of the radius is felt outside of its normal position, while the internal condyle and the trochlear surface are abnormally prominent on the inner side. In the *complete outward* variety both bones are felt to the outer side of the articular surface of the humerus, and the forearm may be in extreme pronation with the sigmoid cavity embracing the outer border of the humerus. In the *inward* variety the sigmoid cavity is felt to the inner side of the trochlear surface, against which the head of the radius may rest while the external condyle and capitellum humeri are abnormally prominent. Instead of being *directly* inward or outward, the displacement is sometimes also backward with either variety of lateral dislocation. In *divergent dislocation*, in the *anteroposterior* variety, the olecranon is felt above its normal position behind the humerus while the head of the radius occupies a corresponding position in front. The forearm is shortened and extended or slightly flexed. In the

transverse variety the olecranon is felt to the inner side of the humerus, the head of the radius to the outer side, while the articular surface of the humerus can be felt projecting between the two. The forearm is semiflexed. *Dislocation of the ulna alone, backward*, is indicated by the abnormal projection of the olecranon behind while the head of the radius is found to occupy its normal position. The forearm is slightly flexed and pronated. *Dislocation of the Radius Alone.*—In *forward* dislocation there is inability to flex completely the forearm and the head of the radius is felt on the front of the humerus above the capitellum humeri. In *outward* and *backward* displacements the diagnosis is made by recognizing the head of the radius in its abnormal position. In the *downward* variety, or *subluxation*, the diagnosis is made by the history of the case and the following symptoms: The forearm is slightly flexed and pronated; neither complete flexion, extension, nor supination can be made without pain and resistance; pressure over the head of the radius causes pain, and sometimes a space can be felt between the head of the radius and the capitellum humeri.

Complications may be fracture, compound dislocation, displacement or injury of the ulnar nerve.

Treatment.—To reduce *backward dislocation* of both bones, or of the ulna alone, flex the forearm slightly, take hold of the elbow with both hands, with the fingers over the ends of the olecranon and radius, while the thumbs are superposed over the lower end of the front of the humerus. In this position press the humerus backward with the thumbs, and draw the olecranon and radius forward with the fingers until the coronoid process slips over the trochlear surface of the humerus. If this method fail under an anæsthetic, make *traction* on the forearm in complete extension, or even hyper-extension, until the coronoid process is released from the olecranon fossa; then employ flexion, aided possibly by downward pressure on the olecranon. In *anterior* dislocation of both bones or of the olecranon alone, flex the forearm over the knee, if necessary, pressing or pulling the upper end of the forearm downward and backward. *Lateral* dislocations can often be reduced by *direct reposition*, if needful extending or hyperextending the forearm. The reduction of *divergent* dislocations seems to have been accomplished with considerable difficulty in some cases by traction and manipulation. In *forward* dislocation of the head of the radius, flex the forearm to relax the biceps muscle, then press the head of the bone into its place in the lesser sigmoid cavity and on the capitellum humeri, and fix the forearm in flexion. In *outward* dislocation of the head of the radius, press the head downward and inward while making extension and counter-

outward until its inner border rests against the outer side of the external condyle. In the *inward* variety these positions are reversed. *Rotary dislocation* may be *complete* or *incomplete*, and, according to the direction in which the toes are turned, *outward* or *inward*. In the *complete outward* variety the tibia is rotated on an axis passing through the centre of the bone, so that its internal articular cavity is displaced forward and outward, while its external articular cavity is displaced backward and inward. In *partial external* dislocation the leg is rotated on an axis passing through the inner condyle of the femur, so that the outer articular cavity is displaced backward from the external condyle of the femur, while the inner articular cavity remains in contact with the internal condyle of the femur, upon which it rotates.

Complications may be fracture of the tibia, femur, or patella, laceration of the popliteal vessels or nerves, or compound dislocations.

Treatment.—Reduce by traction, pressure, and rotation, and fix the joint by means of a gypsum cast for six or eight weeks. Always examine the posterior tibial pulse in order to ascertain the condition of the popliteal artery. If ruptured, a tumor may be felt in the popliteal region, with absence of pulsation in the posterior tibial. Injury to the popliteal vein may be indicated by swelling in the popliteal region and congestion of the leg and foot. In dislocations complicated by injury to the popliteal vessels, unless compound, expectant treatment may be tried for a few days. Elevate the limb, envelop in cotton, and keep warm. Amputate on the appearance of the first symptoms of gangrene. (See COMPOUND DISLOCATIONS, page 305.)

DISLOCATIONS OF THE FIBULA are rare, and may occur at the *upper* end, *forward*, *backward*, or *upward*; and at the *lower* end, *backward*. The *causes* of dislocation are: of the *forward* variety, falls producing inversion of the foot, possibly downward traction on the fibula; of *backward* displacement, contraction of the biceps muscle; of *upward* dislocation, eversion of the foot, as in Pott's fracture, the fibula being pushed upward instead of breaking. The *lower* end of the fibula is displaced *backward* by forcible eversion and abduction of the foot.

Treatment.—All varieties of displacement of the fibula can usually be reduced by pressure and manipulation, and can be kept in position by bandages.

DISLOCATIONS OF THE ANKLE.—Dislocations of the ankle-joint may be *backward*, *forward*, *inward*, *outward*, and *upward*. The *causes* generally are forcible extension, flexion, inversion, or eversion of the foot, falls from a height, striking on the feet, or injuries by machinery. The *backward* variety may be caused by exaggerated extension of the

foot. The astragalus is felt behind the lower end of the tibia, which rests on the scaphoid bone or the neck of the astragalus. The heel is abnormally prominent, and the foot is shortened in front. *Forward* dislocation may be caused by exaggerated *flexion* of the foot. The astragalus with the foot passes in front of the lower end of the tibia, which rests on the os calcis behind the astragalus. The heel is shortened, while the foot is lengthened in front, and the malleoli may be nearer the sole of the foot than normal. *Lateral* dislocations are usually caused by inversion or eversion of the foot, the astragalus escaping in front of or behind the malleolus, on the side opposite that towards which the foot is turned. The *outward* variety usually accompanies Pott's fracture. *Upward* dislocation is caused by a fall, striking on the sole of the foot, so that the astragalus passes upward between the tibia and the fibula. The ankle-joint is broadened, the distance between the malleoli is increased, and their tips approach nearer to the sole of the foot.

FIG. 200.—Forward dislocation of the ankle.

Treatment.—Reduction is usually effected under anæsthesia by first flexing the leg on the thigh in order to relax the calf muscles, then by extension and counterextension and pressure the bones are forced into position. Subcutaneous division of the tendo Achillis may be necessary.

DISLOCATION OF THE ASTRAGALUS ALONE is more frequent than that of the ankle-joint, and may be *forward*, *backward*, to *either side*, or rotated on any of its axes. The *causes* are usually falls from a height or twisting of the foot.

Treatment.—Under anæsthesia attempt reduction, and if found impossible, especially if a compound dislocation, excise the bone.

SUBASTRAGALOID DISLOCATION is a rare form in which the os calcis and scaphoid with the rest of the foot are separated from the astragalus, *inward*, *outward*, *backward*, or *forward*. Dislocation of the ankle is excluded by finding the astragalus in its normal position.

DISLOCATIONS OF THE TARSUS, METATARSUS, AND PHALANGES.—Displacement may occur of any single tarsal bone, or at the medio-tarsal joint. The metatarsal bones may be displaced separately, or all together in any one of four directions. Dislocations of the phalanges correspond with similar injuries to the fingers. On account of the danger of tetanus in wounds of the extremities, especial care should be taken to prevent infection in compound dislocations of the foot.

CHAPTER IV.

SURGERY OF MUSCLES, TENDONS, AND BURSÆ.

STRAINS OR SPRAINS AND RUPTURE OF MUSCLES.—These are injuries in which the muscular fibres are stretched or ruptured as a result of sudden contraction, as in "lawn-tennis arm or leg" in which only a few muscular fibres are ruptured. In other cases an entire muscle may be torn across. Those most frequently affected are the calf muscles, the biceps, flexors of the forearm, rectus femoris, and rectus abdominis. Fatty degeneration is often a predisposing cause. The *symptoms* are sharp pain, followed by soreness or myalgia. When complete *rupture* takes place there is a loss of function and a gap may be felt between the ends of the muscle.

Treatment.—Secure rest by the use of adhesive straps, bandages, or splints. In complete rupture approximate the ends of the muscle by animal sutures.

TENOSYNOVITIS, OR THECITIS, means inflammation of the synovial sheath of a tendon. It may be acute or chronic, and suppurative or non-suppurative.

ACUTE NON-SUPPURATIVE THECITIS is generally due to traumatism, rheumatism, syphilis, or gonorrhœa. The *symptoms* are pain, swelling, and dry crepitation when the tendon is moved in its sheath.

Treatment.—Give rest, local applications of tincture of iodine, or chloroform liniment, followed later by massage and constitutional remedies.

ACUTE SUPPURATIVE THECITIS is caused by infection with pyogenic organisms, usually through an open wound. The *symptoms* are deep-seated, intense, throbbing pain, tenderness, sometimes redness along the course of the tendon, and, in severe cases, chill and fever. The inflammation may extend to the common synovial sheath, or the sheath of the long flexor of the thumb in the palm of the hand, producing *palmar abscess.* Palmar abscess is more likely to follow infection of the little finger or the thumb, their synovial sheaths passing into the palm without interruption, than that of the other fingers. The *symptoms* of palmar abscess are throbbing pain, with swelling, œdema, tenderness of the hand; fluctuation may be detected, and if neglected, the pus may pass between the metacarpal bones and point on the back of the hand.

Treatment.—On the first appearance of tenderness and throbbing pain, make free incisions into the sheath of the tendon affected. In

palmar abscess avoid wounding the palmar arches by careful dissection, or by cutting below the line of the extended thumb and directly over the metacarpal bones. It is often advisable to make three openings in the palm, and in bad cases two or more on the dorsal surface between the metacarpal bones. Scrape out diseased tissue, disinfect with bichloride solution, and pack with iodoform gauze. Later, massage and passive movements may prevent crippling of the hand which is otherwise apt to follow.

CHRONIC TENOSYNOVITIS is nearly always tuberculous and affects especially the tendons of the fingers, wrist, forearm, ankle, and knee. It may appear as a firm swelling composed of granulation tissue or as an accumulation of fluid which may contain small bodies resembling rice kernels or melon seeds attached to the sheath or floating freely in the fluid. These bodies often contain tubercle bacilli.

Symptoms.—There is little or no *pain*, merely stiffness and weakness, sometimes following a slight injury; crepitus; swelling, often spindle-shaped and firm, or fluctuating. When the fluid in the tendon sheath extends from the hand to the wrist beneath the annular ligament, it forms an hour-glass-like swelling, known as "compound ganglion." The disease progresses slowly, may disappear spontaneously, break down into abscesses, or extend to the forearm or neighboring joints.

Treatment.—If fluid be present, remove by aspiration and fill the cavity with a 10 per cent. iodoform emulsion, repeating every week or ten days. If there is much granulation tissue or melon-seed bodies, lay open the sheaths and remove all the diseased tissue, resecting and splicing tendons when necessary. If the disease continue to recur after repeated operations, amputation should be performed.

Prognosis.—Recurrence is frequent, and visceral tuberculosis often causes death.

PARONYCHIA, or "RUNAROUND," is a superficial cellulitis occurring often in weak children about the nails on the fingers or toes. The *cause* is infection by pyogenic organisms through a slight wound which may escape observation, as a hang-nail or abrasion. The *symptoms* are *pain*, *redness*, and *swelling* around or beneath the nail, with suppuration and loss of the nail.

Treatment.—Make incisions early and dress with hot boracic acid solution, frequently renewed. Remove the nail if its presence interfere with the escape of pus. Constitutional remedies are important.

WHITLOW, OR "FELON," is a pyogenic infection of the tendon insertion and periosteum of the ungual phalanges of the fingers and toes, the organisms entering through a slight wound and travelling down the fibrous trabeculæ leading from the skin to the periosteum. The

symptoms begin with a feeling of tension, heat, tenderness, and severe throbbing pain in the palmar surface of the end of the finger, preventing sleep. It may be followed by necrosis of the bone or the infection may extend to the palm and produce palmar abscess.

Treatment.—Give a general anæsthetic, or if anæsthesia is not used tie a rubber tube tightly around the finger above the felon, and make a free incision through the palmar surface to the bone. Dress with hot bichloride or boracic acid solution and renew at frequent intervals.

GANGLION is a hard, round, painless swelling, of slow growth, usually seen on the back of the hand or foot, closely connected with

FIG. 201.—Ganglion on back of hand.

the tendon. It is a *cystoma*, developing from the synovial follicles of the sheath or from the subsynovial bodies of Henle.

Treatment.—Evacuate the syrup-like contents of the cyst subcutaneously by means of an exploring needle or a narrow-bladed bistoury, and if it recur dissect it out.

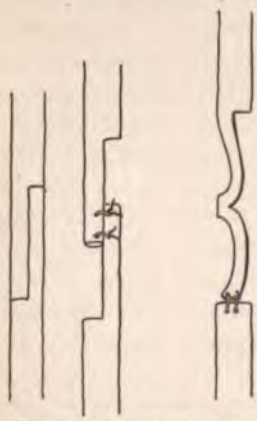

FIG. 202.—Lengthening of tendons.

WOUNDS AND RUPTURE OF TENDONS.—Tendons may be divided by accident, or by the surgeon purposely in order to produce shortening or elongation. Tendons may rupture by sudden effort, especially the quadriceps extensor, the long head of the biceps, the ligamentum patellæ, the triceps, and the tendo Achillis. Treat severed tendons by making an incision, finding the ends of the tendon, and suturing them together with fine silk. Then fix the parts in a position to relax the tendon until recovery takes place. In old cases, find the ends of the tendon by dissection, freshen, and unite them. *Elongation* of a tendon is obtained by cutting a flap from one or both ends, turning it towards and uniting it to the opposite end; by dividing the tendon obliquely and uniting the ends; by trans-

plantation of a tendon from a lower animal; or by the use of strands of animal suture to bridge the gap between the ends of the tendon. When only one end of a tendon can be found it may be attached to a neighboring uninjured muscle or tendon.

The long head of the biceps and the tendon of the peroneus brevis or of the tibialis posticus *may be displaced* from their bony grooves as a complication of fracture, dislocation, or sprain. They should be replaced and retained by compresses and adhesive plaster, or, if this be impossible, operate and secure the tendon in place by suturing a flap of periosteum or of fibrous tissue across it.

BURSITIS may be *acute* or *chronic*, and may affect the superficial or deep bursæ,—most frequently the bursa over the patella, the olecranon (miner's elbow), the metatarsophalangeal joint of the great toe (bunion), and that under the semimembranosus tendon. The *causes* are injury, excessive use, or infection—especially with the tubercle bacillus in chronic cases. There is increased secretion, which may be normal in quality or mixed with blood or pus. The walls of the sac are thickened and fibrous in character and occasionally bony. *Housemaid's knee* is inflammation of the prepatellar bursa, though in some cases the subligamentous bursa is the seat of the disease. The *cause* is long-continued irritation or frequently repeated injuries from kneeling—hence the name. The *symptoms* are a globular, fluctuating swelling at the lower border of the patella; if *acute*, pain, tenderness, and redness of the skin. If the subligamentous bursa be affected, instead of a globular swelling in the middle line there will probably be a swelling on each side of the ligamentum patellæ, pressure on one side producing fluctuation in the other; or if a single swelling exist, it will be on the side of the ligamentum patellæ, and not in the median line.

FIG. 203.—Housemaid's knee.

Treatment.—The most rational treatment of *chronic* bursitis is to remove the cause by protecting the knees or elbows, if necessary, by means of pads and by wearing properly constructed shoes. Tincture of iodine, blisters, and compression with elastic bandages may be tried. Aspiration, with the injection of carbolic acid or tincture of iodine, may be used for the obliteration of superficial bursæ or those known not to communicate with a joint. The surest method is to dissect out the bursa and close the wound. In *acute bursitis* give rest, elevate the part, and apply heat or cold. If suppuration occur, open freely, disinfect, and pack with gauze.

CHAPTER V.

ORTHOPÆDIC SURGERY.

ORTHOPÆDIC SURGERY has for its object the correction of deformities, congenital or acquired,—the treatment of the results of diseases and injuries rather than the diseases and injuries themselves.

TORTICOLLIS, or WRY-NECK, is a contracted condition of one or more of the muscles of the neck, causing a more or less permanent deviation of the head from its normal position. The sternocleidomastoid muscle is the one most frequently involved, but the platysma, the trapezius, the splenius, the scaleni, and the complexus are sometimes affected.

Varieties.—It may be congenital or acquired, acute or chronic, and spastic or spasmodic, and is more frequent in young children and on the right side. The *causes* may be cold, inflammation, injury to the nerves, nerve centers, or muscles. It may be compensatory, as in scoliosis or in disease of the eyes. *Spasmodic* and *spastic* cases are more apt to occur in adults, from a central nervous lesion, a hysterical condition, or disease of the spinal accessory nerve. The contracted muscles are hard and fibrous, the ligaments are contracted on the same side, and changes sometimes take place even in the bones and cartilages.

Symptoms.—In the most common variety the face is turned to the opposite side, the chin is extended, and the ear drawn towards the shoulder of the affected side, while the sternomastoid muscle may be felt as a firm, contracted cord. The face and skull may be asymmetric. The *acute* variety, which may be due to cold or inflammation in the muscle, may be accompanied by pain and elevation of temperature. In the variety which occurs in adults, the spasm is usually clonic, but is sometimes tonic or spastic.

Treatment.—In acute cases massage and apply heat. Treat rheumatic tendencies with salicylate of sodium or potassium iodide. In the chronic form divide the sternocleidomastoid muscle at its origin, either by an open incision or by subcutaneous tenotomy, avoiding the internal jugular vein. After operation fix the head in an overcorrected position by means of a gypsum cast, which may be renewed from time to time, but should be worn for from one to six months. If other muscles are affected, correct the deformity by force under an

anæsthetic. In spasmodic and spastic torticollis, expose the spinal accessory nerve by an incision along the posterior border of the sterno-mastoid muscle, one to two inches below the mastoid process, and resect half an inch of the nerve. The upper cervical nerves may require resection.

CONTRACTURE is permanent contraction of a muscle. It is seen in club-foot and in old cases of paralysis and requires tenotomy with lengthening of the tendon.

DUPUYTREN'S CONTRACTION is a contraction of the palmar fascia and its digital prolongations, resulting in the permanent flexion of the first phalanges of one or more fingers. It usually occurs in men

FIG. 204.—Palmar fascia: *a*, superficial transverse ligament; *b*, digital arteries and nerves. (After Gray.)

beyond middle age, in the ring, middle, or any finger in one or both hands. The *causes* are supposed to be a rheumatic, gouty, or syphilitic diathesis, reflex nervous irritation, or the frequent repetition of slight traumatism.

Symptoms.—It begins as a hard, painless nodule in the palm of the hand, near the metacarpophalangeal articulation, which gradually extends above and below, causing flexion of the first phalanx of the finger. Neuralgic pains are sometimes felt in the forearm. The

diagnosis must be made from the contraction of ordinary scars or of the flexor tendons.

Treatment.—Divide the contracted fascia subcutaneously in several places; or, better, turn up a V-shaped flap and dissect out the contracted tissue, sew the flap in place, and apply a splint to keep the fingers straight.

TRIGGER FINGER is caused by a local enlargement of the flexor tendon from tenosynovitis, or the presence of a tumor, or contraction of the groove in the transverse ligament, so that the normal action of the tendon is hindered. The *symptoms* are a sudden catch in the finger during flexion or extension, which can be felt on grasping the finger. The obstruction may be removed by operation or passive motion.

CLUB-HAND is a deformity of the hand analogous to club-foot, with abnormal deviation of the hand in any one of the four directions, of flexion, extension, adduction, or abduction—usually abduction. It may be congenital or result from wounds of the wrist. The *treatment*, in bad cases, is not satisfactory. If tenotomy is done, splice the tendons. Osteotomy or resection of the bones may improve the deformity.

SYNDACTYLISM is a congenital, often hereditary, affection of two or more fingers, usually the middle and ring fingers, of one or both hands, in which the fingers are united in part, or in their entire length, by a web of skin which sometimes contains muscle and fibrous tissue, or the phalanges of the two fingers may be closely approximated, or the bones may be fused together. The toes are sometimes similarly affected.

FIG. 205.—Didot's operation for webbed fingers.

Didot's operation gives the best result. A longitudinal incision is made along the palmar surface of one finger, the length of the web, and a like incision on the dorsal surface of the other finger. These flaps are detached, at the same time splitting the web, so that when the flaps are applied in their new position half of the palmar surface of one finger is covered by the flap taken from the dorsum of the other finger, which, in turn is covered by the palmar flap taken from its fellow.

POLYDACTYLISM, or SUPERNUMERARY DIGITS, is also a congenital and sometimes hereditary condition, affecting one, two, or all four extremities. The extra digit is usually attached to the ulnar side of the other finger by a slender pedicle, or it may be perfectly formed, including phalanges and metacarpal bone. No treatment is necessary, unless for cosmetic reasons, when the extra digit may be amputated.

COXA VARA is a downward bending of the neck of the femur, the head of the bone sometimes reaching a level below that of the trochanter major. It occurs usually between the thirteenth and eighteenth years, as a result of rickets, in those who stand or walk a great deal and carry heavy burdens.

Symptoms.—The patient tires easily and has a limp, but no sign of inflammation. The top of the trochanter rises above Nélaton's line, and there is shortening, sometimes external rotation and adduction, but the motion of the joint is normal.

Treatment.—Prevent further bending by removing pressure on the bone, as in hip disease, until hardening takes place, and give constitutional treatment for rickets.

GENU VALGUM.—Knock-knee is an abnormal angular projection of one or both knees towards the median line. It is more frequent in boys between two and four years of age, as a result of abnormal development from rickets causing obliquity of the femoral epiphysis with enlargement of the internal condyle and elongation of the internal lateral ligaments. Other causes are chronic disease of the knee-joint, paralysis, traumatism, feeble muscular development, and, in young adults, occupations requiring long standing with the feet widely separated.

Treatment.—For patients under four years of age a brace may be attached to the outer side of the extremity by means of straps which draw the knee outward; it should be worn for a year or two. In older children do an osteotomy just above the epiphyseal junction. Make a longitudinal incision, an inch long, down to the bone, on the inner side of the femur, a finger's breadth above the upper border of the patella, when the leg is extended, or just above the adductor tubercle on the inner side; insert a chisel, turn it at right angles to the incision; divide the bone for about three-fourths of its thickness, and break the uncut portion by bending the limb to the opposite side. Look out for the popliteal vessels. Sometimes osteotomy of the tibia and fibula is necessary. Straighten the limb, apply a dressing and gypsum cast, and treat as a fracture.

GENU EXTRORSUM—bow-leg—is an abnormal outward deviation of one or both knees, the curve being in the shaft of the femur, in the

tibia, or in both. The *causes* are usually muscular action in rickets and attempts to walk before the bones become hard, occasionally osteitis deformans or fracture.

Treatment.—As the child develops, the deformity may be spontaneously corrected. This may be assisted by massage and gently bending the bones into proper shape several times daily. Mechanical apparatus or operative measures should be adopted, according to the principles already explained in the treatment of genu valgum.

ANTEROPOSTERIOR CURVATURES of the tibia and fibula are sometimes seen, usually with the convexity forward.

GENU RECURVATUM is an abnormal extension of the leg, causing the knee-joint to project backward, and is probably caused by relaxation of the posterior ligaments of the knee with contraction of the anterior portion of the capsular and lateral ligaments. The *treatment* consists in massage and bending the knee into its proper position, the use of gypsum casts, or the subcutaneous division of the contracted ligaments.

TALIPES.—Talipes ("ankle-foot"), or club-foot, is an abnormal deviation of the foot in any one of the four lines of movement, or a

FIG. 206.—Talipes equinovarus, posterior and anterior view. (Wharton and Curtis.)

combination of two of these, thus giving the following varieties: Talipes varus (adduction), talipes valgus (abduction), talipes equinus (extension), talipes calcaneus (flexion), talipes equinovarus (combination of equinus and varus), talipes cavus (hollow-foot), talipes planus (flat-foot), and "hysterical talipes."

Talipes equinovarus is the most common congenital form of club-foot, and occurs more frequently in males, in both feet; but if in one, it is oftener the right. The foot is inverted, the sole presenting inward, the inner border raised, the outer border or even the dorsal surface resting on the ground; the heel is elevated, and the anterior part of the foot is usually flexed at the mediotarsal joint.

Talipes valgus, commonly acquired, in weakly children or adults, is more frequent than simple varus. The foot is abducted and everted, with loss of the arch and prominence of the scaphoid and astragalus on the inner side, upon which the foot rests, while the outer border may be elevated.

Talipes equinus is usually acquired. The heel is raised, and the patient walks on the ends of the metatarsal bones. In severe cases the head of the astragalus projects upon the dorsum above the scaphoid, and there is contraction of the plantar ligaments and fascia as well as of the tendo Achillis.

Talipes calcaneus, usually acquired, is the opposite of equinus, and is often associated with valgus, forming calcaneovalgus. The patient walks on the heel, while the anterior portion of the foot is elevated and abducted.

Talipes cavus (hollow-foot), usually acquired, consists in an exaggeration of the arch of the foot from paralysis of the calf muscles and contraction of the plantar fascia, the tibialis anticus, and the peroneus longus muscles. It is often associated with equinovarus. The heel and ball of the foot and toes rest on the ground, while the dorsum is elevated and prominent.

Pes planus, or flat-foot, the opposite of *cavus*, is a moderate form of *valgus*, the arch being lost, permitting the tarsal bones to rest on the ground without eversion of the foot.

The *causes* generally given of *congenital* club-foot are heredity, maternal impressions, the marriage of near blood-relations, disease in utero causing paralysis of certain groups of muscles (Little), that *varus* is a normal condition in utero and rotation sometimes fails to take place (Berg), and mechanical pressure in utero or arrested development of the tarsal bones.

The *causes* of the *acquired* forms are disease,—anterior poliomyelitis or rickets; traumatism, as burns, cuts, or fracture; and certain *vocations*, as of bakers, peddlers, sailors, or floor-walkers.

Pathological changes are alteration in position and shape of the bones; contractions or stretching of the tendons, fasciæ, and skin; and the formation of bursæ over parts subjected to abnormal pressure.

Treatment.—During the first three months after birth massage and

manipulate, pressing the foot into its normal shape several times daily, or, if necessary, use a light gypsum cast, which should be changed at least once a week. After three months, should the case seem unsuited for further treatment by manipulation or mechanical apparatus alone, some form of operation is necessary. *Brisement forcé* is forcible correction of the deformity under an anæsthetic. It may be done by instruments made for the purpose, but preferably by the hands of the surgeon. There is more or less rupture of the contracted tendons, fasciæ, and ligaments. The deformity should be over-corrected and the foot and leg placed in a gypsum cast. *Tenotomy.*—In *equinovarus* the *varus* may first be corrected by cutting the tibialis anticus and occasionally the tibialis posticus and the plantar fascia. Tenotomize the tibialis anticus, slipping the tenotome beneath the tendon about two inches above its insertion and cutting towards the skin; the tibialis posticus, by an open wound, and cutting the first tendon behind the internal malleolus; and the plantar fascia, by passing a long-bladed tenotome beneath the fascia from the inner side, and while the fascia is made tense dividing it by cutting towards the sole of the foot until it is felt to give way. The tendo Achillis may be divided at the same time, or the operation may be deferred for some months, until the varus has been cured. It may be divided subcutaneously, or by open incision and elongated. After tenotomy, forcibly correct the foot, dress the wounds, and use plaster casts until the wounds heal; then massage and manipulation; or if the child is old enough to walk, a club-foot shoe must be worn. Phelps makes an incision, one-half or two-thirds across the sole of the foot, just in front of the internal malleolus, dividing all the tissues down to the bones. The foot is then straightened, dressed, and the gap allowed to fill by granulation. *Excision of bones*—the astragalus, scaphoid, cuboid, or a wedge-shaped piece of the tarsus—may be required in old cases. *Talipes calcaneus*, in addition to mechanical treatment, may require tenotomy of the flexor tendons of the foot or shortening of the tendo Achillis. *Talipes cavus*, or hollow-foot, may be treated mechanically by the use of a shoe with a steel sole, or in severe cases by division of the contracted plantar fascia and tendons. For *talipes planus* raise the inner border of the foot by having the sole of the shoe thicker on this side, or use Whitman's brace—a plate of thin, tempered steel adapted to fit the sole of the foot in its normal shape—in the shoe. In severe cases, before applying the apparatus, bend the foot into shape under anæsthesia. *Paralytic forms of club-foot* should be treated by mechanical apparatus, elastic traction to reinforce the paralyzed muscles, the use of electricity, massage, and hypodermatic injections of strychnine.

WEAK ANKLES are due to relaxation or feeble development of

the tendons and ligaments about the ankle. The child may walk flat-footed, and the ankle easily turns, so that he may fall frequently. The *treatment* consists in improving the general condition and using braces of leather or steel.

TARSALGIA AND METATARSALGIA are neuralgic conditions; the former is often a symptom of flat-foot, and the treatment should be directed to that deformity. *Metatarsalgia* is due to pressure on filaments of the plantar digital nerves from crowding together of the heads of the metatarsal bones by wearing ill-fitting shoes (T. G. Morton), or to breaking down of the transverse arch formed by the heads of the metatarsal bones (Goldthwaite). The *symptoms* are severe, radiating pain about the heads of the metatarsal bones, especially the fourth, tenderness on pressure, but no evidence of inflammation. The *treatment* consists in the use of properly-fitting shoes, fixing the foot in a plaster-of-Paris bandage, or, in inveterate cases, excision of the head of the offending metatarsal bone.

HALLUX VALGUS is abnormal outward deviation of the great toe. The opposite condition, hallux *varus*, is rare.

Etiology and Pathology.—The cause of hallux valgus is nearly always the use of shoes with narrow soles and pointed toes; sometimes it is due to gout or rheumatism. The great toe is subluxated outward, leaving the head of the metatarsal bone abnormally prominent, pressure upon which causes enlargement, the formation of a bunion, a corn over the bunion, and often inflammation which extends to the periosteum and bone.

Treatment.—Use wide, properly-shaped shoes. In severe cases excise the head of the metatarsal bone through an incision on the dorsal surface, in order to protect the scar from pressure.

HAMMER-TOE.—Another tribute in the shape of deformity which foolish persons pay to the Moloch of fashion is an angular deformity, usually of the second or little toe, at the first phalangeal articulation, in which the first phalanx is extended, the second phalanx strongly flexed, and the third phalanx either extended or in line of flexion with the second. It is most frequent in children or young adults, and is due to contraction of the lower fibres of the lateral ligaments of the first phalangeal joint. To correct the deformity divide the lateral ligaments, straighten the toe, and use a splint until recovery takes place. In severe cases amputate the toe.

CHAPTER VI.

SURGERY OF THE NERVOUS SYSTEM, INCLUDING THE HEAD AND SPINE.

Surgery of the Head.

CRANIAL TOPOGRAPHY AND CEREBRAL LOCALIZATION.

THE five fissures in the brain of special surgical importance are the *median fissure*, indicated by a line drawn from the glabella (the smooth swelling between the eyebrows) to the inion (the external occipital protuberance), about half an inch to the right of the median line in right-handed persons, as the left cerebral hemisphere is larger than the right. This fissure contains the superior longitudinal sinus. The *fissure of Bichat*, indicated by a line drawn from the

FIG. 207.—Relations of cerebral convolutions to the skull. (After Gray.)

inion to the external auditory meatus. This fissure separates the cerebellum from the cerebrum and contains the tentorium cerebelli and the lateral sinuses. The *fissure of Rolando*, the most important of all, which starts, according to Thane, from a point $55\frac{7}{10}$ per cent. of the distance from the glabella to the inion and runs downward and forward for about $3\frac{1}{4}$ inches at an angle of 67°. In children

this fissure is more oblique, to 52°, and nearer the front. *Chiene's Method for Locating the Fissure of Rolando.*—Take a square piece of paper which represents 90°; fold it diagonally. This represents 45°. Fold again one of the sides which represents 45°, and let it remain folded while the rest of the paper is straightened out. This represents 67½°. Apply the apex of this triangle to a point half an inch behind the centre of the distance from the glabella to the inion and one of the sides of the triangle to the middle line in front of this point. The other side of the triangle will indicate the fissure of Rolando. *Krönlein's Method.*—Draw a horizontal line

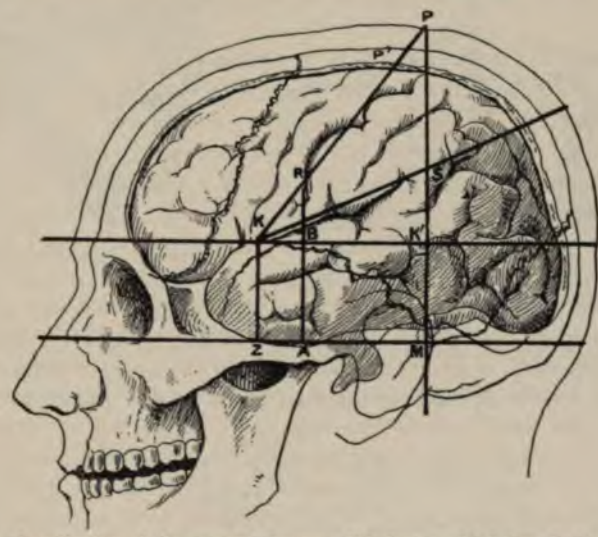

FIG. 208.—Localization of the cerebral fissures: *K S*, fissure of Sylvius; *R P'*, fissure of Rolando; *K* and *K'* indicate points for trephining for hemorrhage from the anterior and posterior branches of the middle meningeal artery; *A B K' M*, Von Bergmann's quadrangle, area for trephining for abscess of the temporosphenoidal lobe. (After Krönlein).

through the lower border of the orbit and the upper border of the auditory meatus. Draw a second line parallel with this, on a level with the supraorbital ridge. Connect these lines by a vertical line from the middle of the zygoma. Draw a second vertical line from the articulation of the lower jaw to a point about two inches above the second horizontal line. Draw a third vertical line from the posterior border of the base of the mastoid process to the middle line of the top of the skull. Draw a line from this last point to the intersection of the upper horizontal and the first vertical lines. Its upper two-thirds will correspond to the fissure of Rolando. Bisect the angle made by the last line and the upper horizontal line, and the bisecting

line will correspond to the fissure of Sylvius from its bifurcation to its posterior end. *Horsley's cyrtometer* is an instrument for locating the fissure of Rolando. It may be made of metal or thick paper, and consists of an anteroposterior strip about fourteen inches long, to

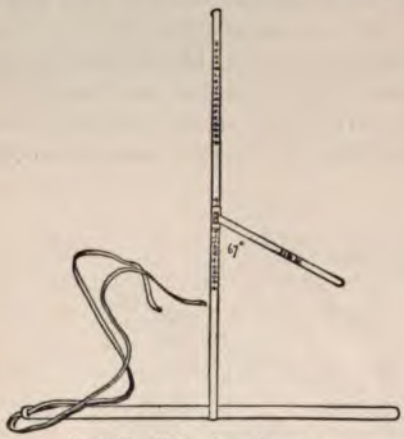

FIG. 209.—Wilson's cyrtometer.

FIG. 210.—Cyrtometer applied.

which a lateral strip about four inches long is attached at a point one-half inch behind the centre, at an angle of 67° with the anterior arm. The anteroposterior arm is numbered in both directions from the zero point, which is half an inch in front of the attachment of the

FIG. 211.—Cerebral convolutions and centres. (Wharton and Curtis.)

lateral arm. Place the instrument on the head so that corresponding numbers—for example, six and three-fourths inches—shall rest on both the glabella and inion. The lateral arm will indicate the fissure of Rolando. The *fissure of Sylvius* is indicated by drawing a line

from the external angular process of the frontal bone to the occipital protuberance. The *fissure of Sylvius* begins one and one-eighth inches posterior to the external angular process on this line, and the main branch is indicated by a line drawn from this point to the parietal eminence. The ascending branch of the fissure begins about two inches behind the external angular process, corresponding to the squamoso-sphenoidal suture, and extends upward about half an inch. The *intraparietal fissure* begins opposite the junction of the middle and inferior thirds of the fissure of Rolando and passes upward, lying midway between the fissure of Rolando and the parietal eminence, then curving backward midway between the parietal eminence and the superior longitudinal fissure.

The motor areas of the brain are grouped in front of and behind the fissure of Rolando, being limited posteriorly by the intraparietal fissure. Dividing the fissure of Rolando into thirds, in a general way it may be said that the centres for the leg lie about the upper third; the centres for the shoulder, elbow, and hand about the middle third; and the centres for the face, mouth, and larynx about the lower third. The centres for the trunk, also for the face and leg, are situated on the median surface of the hemisphere as well as on its external surface.

THE GENERAL TECHNIQUE OF CEREBRAL OPERATIONS.

In preparing for any operation on the brain, shave the entire scalp and disinfect it thoroughly three days before the operation; if practicable, a second shaving and disinfection being done on the day of the operation. Unless there is some contraindication, chloroform is the best anæsthetic, as it produces less cerebral congestion than ether.

FIG. 212.—Devilbiss cranial gouging forceps.

A large flap should be made, of a semicircular shape, with the base containing the principal arteries. An osteoplastic flap (scalp and bone kept together) may be made, the bone being cut with mallet and chisel, surgical engine, or Gigli wire saw through small trephine

openings and restored to its place after the operation. The opening may be made with a trephine and enlarged to any desired extent by rongeur forceps. The dura mater should be carefully examined as to its color, density, tension, and the presence or absence of pulsation. If necessary, open it by raising a flap, cutting far enough from the edge of the bone to permit of the introduction of sutures in closing the dural opening. *Hemorrhage* from the *bone* may be arrested by hot water or pressure; from the *dura mater*, by passing a suture around the vessel and tying it; from a *sinus* in the brain, by pressure, by a lateral ligature or suture, or, if necessary, by ligation; and from the *brain tissue*, by packing, or by a suture ligature of fine catgut gently tied. After exposing the surface of the brain, certain motor centres may be identified by using a weak faradic current through a double brain electrode. As a rule, drainage should not be used except in cases of cysts, abscesses, and infected wounds. Do not replace bone unless an osteoplastic flap has been made. The after-treatment consists in keeping the patient quiet, free from noise and excitement, with the head slightly elevated, and the bowels should be kept well regulated. If no drainage has been provided, watch for symptoms of pressure, and if they arise, search for fluid by separating the edges of the wound with a director. The stitches may be removed as soon as firm union has taken place, usually about the tenth day.

Hernia, or *fungus cerebri*, a troublesome complication of wounds of the brain and dura, especially septic wounds, appears as a rounded or irregular, soft projection from the brain, of bloody, grayish-white appearance, composed of granulation tissue, painless, but sometimes pulsating. *Treatment.*—The *preventive* treatment consists in securing strict asepsis in operations on the brain, and when the cerebral tissue is wounded and the dura destroyed, dissect off a piece of the pericranium, turn it upside down, and stitch it to the edges of the dura mater, in order to fill in the defect (Keen). After the appearance of the fungus, apply gentle and gradually increasing pressure by means of iodoform gauze until the fungus contracts.

DISEASES AND INJURIES OF THE SCALP AND SKULL.

The scalp is a favorite seat for the development of wens or sebaceous cysts, also nævi, cirsoid aneurism, warts, horns, fibrous and fatty tumors. Pneumatocele, a rare tumor, obliterated temporarily by pressure, is sometimes seen on the scalp. It contains air, resulting from atrophy of the osseous tissue producing a communication with the mastoid cells. The skull may be the seat of caries, necrosis, hypertrophy, or atrophy. Exostoses are sometimes seen as a result of injury or of syphilis. Sarcoma and epithelioma may originate either

from the scalp or skull. Erysipelas and abscess of the scalp are of especial interest on account of the danger of meningitis from the passage of infectious material by means of the veins which pass through the skull to the vessels within. Pus may burrow extensively and may collect above or beneath the aponeurosis of the occipitofrontalis muscle or beneath the pericranium. The *treatment* consists in incision, irrigation, and drainage.

WOUNDS OF THE SCALP.—On account of its great vascularity, wounds of the scalp bleed freely, and for the same reason heal rapidly. The difficulty of cleansing increases the danger of infection and of

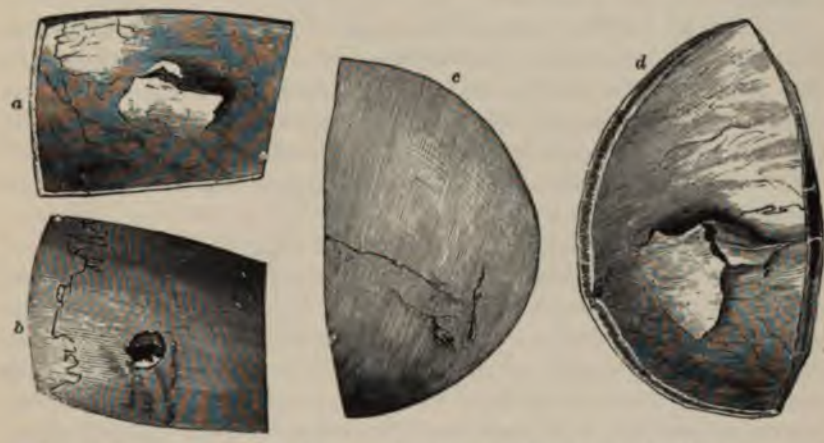

FIG. 213.—Gunshot wound of skull, showing (*a*) splintering of internal table at wound of exit; none at (*b*) point of entrance; (*c*) fissure in external table of skull, with (*d*) splintering of internal table. (Wharton and Curtis.)

abscess. Shave the scalp and thoroughly disinfect the region. Arrest bleeding by grasping with hæmostatic forceps the entire thickness of the scalp, including the blood-vessels, or use a suture ligature. Close the wound with horsehair or silk-worm gut.

FRACTURE OF THE SKULL.—Fractures of the skull are *simple*, *compound*, *complete*, *incomplete*, *depressed*, *punctured*, *stellate*, *fissured*, and by *diastasis*, and, according to region, fractures of the *vault* or of the *base*.

Etiology and Pathology.—The causes are usually direct violence in fractures of the vault, and indirect violence in most fractures of the *base*, either by the extension or radiation of a fracture of the vault or by falls on the feet, buttocks, or vertex, or by a blow on the chin; or directly by pointed instruments, such as canes, umbrellas, knives, forks, or needles thrust through the orbit, the nasal cavity, the ear, or the pharynx. Fracture by contrecoup—that is,

fracture of the opposite side of the skull from that at which the blow was struck—is extremely rare. The majority of these cases are fissures which have radiated from the point at which the violence was applied; or the patient may have received a blow on each side of the head,—having been struck on one side, he falls and strikes the other against the curbstone or pavement. The skull is elastic, and its shape may be altered enough to compress its contents possibly half an inch without fracture,—as shown by Felizet's experiment, in which a skull filled with paraffin and dropped from a height remained unfractured, but a distinct impression was found upon the paraffin.

FRACTURE OF THE VAULT.—A fracture of the vault may be a mere fissure or crack extending through one or more bones of the skull. The bone may be depressed, broken into several fragments, and driven into the brain, leaving a funnel-shaped depression perceptible through the scalp. A fragment of the internal table may be detached from the external table, the latter showing no sign of fracture, or possibly only a fissure.

Symptoms.—Simple fractures of the skull without depression are, as a rule, impossible of diagnosis. A "cracked-pot" sound on percussion, or a pulsating swelling beneath the scalp, becoming tense on straining, may be detected. Do not confuse with hæmatoma, in which solid, smooth bone is felt at the bottom, surrounded by a smooth, firm ring. In *depressed* fracture an irregular surface may be felt at the bottom of the depression, surrounded by hard, irregular, jagged edges. *Compound* fractures with depression are easily recognized, but fissures may be taken for sutures, or tears in the pericranium, or vice versa. Wormian bones may be mistaken for fractures. *Sutures* are generally serrated, and a *fissure* is usually indicated by a dark line of blood which cannot be wiped away. The external table of the *frontal sinuses* may be depressed without injury to the internal table. The *prognosis* depends mainly on the amount of damage to the brain and whether the wound is clean or infected. *Repair* of fractures of the skull resembles that of other bones except that the callus is much less abundant and is produced principally by the diploe. Loss of bone exceeding one inch in diameter is not made good, the opening being filled with fibrous tissue.

Complications.—The immediate dangers are *shock*, *hemorrhage*, and *infection*. The remote dangers are *persistent headache*, *epilepsy*, *insanity*, *abscess*, *tumor*, or *cysts*.

Treatment.—Cases in which fracture is suspected, but not certainly known, and simple fracture with moderate depression without brain symptoms, should be treated expectantly by quiet, restricted diet, and

moderate purgation until all symptoms disappear. In *simple* fractures with *marked* depression, although there may be no brain symptoms, many surgeons advise operation as the safest procedure against future trouble. In *compound* fractures *without* depression and without brain symptoms, disinfect and close the wound without opening the skull. In *compound* fractures *with* depression and in *punctured* wounds of the *brain*, trephine in every case and raise the depressed bone.

FRACTURE OF THE BASE may be simple or compound, and involve the anterior, middle, or posterior fossa, or all three. The *symptoms* are often indefinite and only a probable diagnosis possible. Concussion is usual—compression occasional. *Fracture of the anterior fossa* may be indicated by hemorrhage or the escape of brain tissue through the nose, mouth, or orbit, by severe ecchymosis of the conjunctiva and skin of the eyelids, or by pressure on the nerves of the eye, giving rise to ptosis, squint, dilatation, or irregularity of the pupils. *Fracture of the middle fossa* may be indicated by the escape of blood, brain tissue, or cerebrospinal fluid from the ear; occasionally they flow down the Eustachian tube and escape from the nose or mouth.

Cerebrospinal fluid is differentiated from serum from a blood-clot, the liquor Cotunnii from the labyrinth, or fluid from the mastoid cells, by its greater quantity and by its containing a large amount of salt and a small amount of albumen. The nerves involved may be the optic, the motor oculi, the fourth, fifth, sixth, seventh, or eighth. In *fracture of the posterior fossa*, look for Battle's sign—ecchymosis over the mastoid process caused by blood from the skull following the course of the posterior auricular artery in order to escape through the cervical fascia. Optic neuritis sometimes occurs towards the end of the first week or later. Respiration may be affected and sudden death result from pressure on the medulla oblongata. The *temperature* in fractures of the skull is at first subnormal, during the existence of shock, then slightly elevated (to 100° or 101° F.), followed by a second fall to the normal, where it remains, unless there is some complication, such as serious laceration of the brain or infection, when the temperature rises again to 102°, 106°, or 108°.

The *prognosis* in fractures of the base is more serious than in fractures of the vault. Fractures of the posterior fossa are most fatal, but fortunately least frequent.

Treatment.—Treat *simple* fractures without marked injury to the brain symptomatically and on general principles. In *compound* fractures communicating with the ear, nose, or orbit, disinfect these cavities as thoroughly as practicable with boracic acid solution and pack the nose or ear. Symptoms of brain pressure from fragments of bone, blood-clots, or abscess demand operation. The skull should

be opened over the region which the focal symptoms show to be the seat of the trouble.

DISEASES AND INJURIES OF THE BRAIN AND ITS MEMBRANES.

CONGENITAL HERNIAL PROTRUSIONS through the skull are meningocele, a protrusion of the membranes containing cerebrospinal fluid; cephalocele, a protrusion of membranes, fluid, and brain; and hydrencephalocele, a protrusion of membranes, brain, and fluid, the fluid being contained within the brain tissue and usually communicating with the ventricles. The swelling varies in size from that of a walnut to a cocoanut.

Treatment.—Spontaneous cure occasionally takes place, the opening in the skull closing in with shrinking and obliteration of the protrusion, but the large majority of the patients die early. Pressure may be tried, but the effect should be carefully watched. The only method promising a cure is a radical operation. In suitable cases the membranes may be opened, the contents reduced or resected, and the membranes trimmed and united with sutures.

MICROCEPHALUS is a condition in which it is thought that the normal development of the brain is prevented by the too early ossification of the sutures in the skull and the closure of the fontanels. The *symptoms* are the slow and imperfect development of the faculties, the appearance of the upper teeth before the lower, the small size and hardness of the head, with closure of the fontanels. The *treatment* is *linear craniotomy*, introduced by Lannelongue, of Paris, but first performed by Fuller, of Michigan (Park). Portions of the skull are removed in order to permit the skull to expand and give room for the development of the brain. The letter H may be made by the removal of a longitudinal section half an inch in width on either side, joined by a transverse section.

HYDROCEPHALUS, or dropsy of the brain, is an excessive accumulation of cerebrospinal fluid in the ventricles of the brain. Occasionally in the acute form the accumulation is extra-ventricular. There are two varieties, *congenital* and *acquired*. The *congenital* variety exists at birth, but may not be observed until some months later, when the cranium begins to enlarge, and this enlargement continues to such an extent that the bones are separated at the sutures, the fontanels are widely distended, the forehead projects, and there are symptoms of intracranial pressure, such as headache, strabismus, optic neuritis, vertigo, vomiting, convulsions, and slow pulse. The child is generally backward in intelligence, though occasionally precocious, is rarely able to talk or walk, and usually dies before puberty. *Acquired* or *acute hydrocephalus* is nearly always caused by tuberculous

meningitis, primary or secondary, in children or adults, but more frequently in the former. There is no enlargement of the cranium as in the congenital form, but there are symptoms of inflammation and compression of the brain. Recovery is rare, death occurring within two or three weeks.

Treatment.—Evacuation of the fluid has been revived by Keen and others. This may be done by aspiration or by the use of the trocar and cannula. The puncture may be made through the dilated anterior fontanel, avoiding the longitudinal sinus; by trephining an inch and a quarter behind and above the external auditory meatus and introducing a trocar and cannula in the direction of a point two and a half to three inches above the opposite auditory meatus (Keen); by trephining the occipital bone and opening the subarachnoid space under the cerebellum (Parkin); or by lumbar puncture, in which the trocar and cannula are introduced in the space between the laminæ of the second and third lumbar vertebræ and made to penetrate the sheath of the spinal cord (Quincke). The fluid should be slowly withdrawn, as convulsions sometimes occur. After the withdrawal of the fluid, in congenital cases, compression of the cranium may be tried by means of bandages. Cases of recovery after lumbar puncture have been reported, also after tapping the lateral ventricles (Mayo-Robson and others).

CONCUSSION OF THE BRAIN means a shaking up or commotion of the brain tissue characterized by a transient suspension of some of its functions. The *cause* is always mechanical violence, directly or indirectly applied. It is possible that the vibrations of the skull are transmitted to the cerebrospinal fluid, which in turn acts upon the brain, producing a commotion among the nerve-cells without perceptible anatomical lesion; or that the wave of cerebrospinal fluid is driven into the fourth ventricle, compressing the centres of respiration and circulation (Duret and Miles); but most authorities believe that some anatomical lesion is produced in the large majority of cases and that *concussion* is synonymous with *laceration* or *contusion* of the brain, in both of which there are certain definite, though perhaps minute, solutions of continuity of the nerve-cells, nerve-fibres, and vessels. The wave of cerebrospinal fluid produced by a blow on one side of the head may lacerate the brain on the opposite side,—laceration by *contrecoup*,—much more frequent than fracture by *contrecoup* (Duret and Miles).

Symptoms.—In slight degrees of concussion the patient may not fall, but simply stagger. He is confused, dizzy, or stunned; strength is lost; the eyes droop; the arms drop; the knees give way; the face is pale; respiration is superficial and feeble; the pulse is rapid, small,

and weak; vision, hearing, and speech are disturbed—stars or flashes of light may be seen, strange noises heard, the speech is slow, hesitating, or paralyzed. In severe cases the symptoms are more pronounced, the patient falls and lies apparently unconscious, but may be aroused by a loud voice or by shaking. Muscular relaxation is complete, often involving the sphincters, with involuntary evacuations. There are pallor and coldness of the surface of the body and extremities. The respiration is superficial, sighing, and may be irregular and of the Cheyne-Stokes variety. The pulse is feeble and rapid, but sometimes slow; the pupils may be unequally contracted or dilated, but they react to light. Vomiting may occur and there may be twitching of the muscles or general convulsions. The temperature is subnormal.

The *termination* may be: (1) Normal reaction within twenty-four hours, with vomiting, headache, and lassitude. (2) Excessive reaction with mental disturbance, such as great irritability, restlessness, delirium lasting days or even weeks, and which may be due to or followed by meningitis, and encephalitis, or cerebral abscess. (3) Coma, lasting several days, or ending in death from compression.

The *prognosis* is favorable. Occasionally inflammation, abscess, or chronic headache may result.

Treatment.—Slight cases require no treatment except quiet in the recumbent position until reaction takes place. In severe cases stimulation may be necessary. Aromatic spirits of ammonia, or hypodermatic injection of strychnine are the best. Put the patient to bed in a moderately darkened room and keep him quiet, free from noise or company, with light diet, an occasional purgative, and advise against return to business for at least a week after all symptoms have subsided.

COMPRESSION OF THE BRAIN is the result of encroachment on the space normally occupied by the brain, or of anything which diminishes the capacity of the cranium or adds to its contents, such as depressed bone, foreign bodies, hemorrhage, etc. The line of demarcation between concussion and compression is often ill defined, and compression is sometimes a sequel of concussion. The *symptoms* usually come on more slowly than in concussion, with headache, restlessness, irritation, stupor, delirium, or drowsiness, and often complete unconsciousness from which the patient cannot be aroused. The skin is hot and flushed rather than cold, and is sometimes covered with perspiration. The pulse is full, slow,—40 to 60 to the minute,—and may be irregular. In the last stages it becomes rapid and small. The respirations are slow, stertorous, with puffing of the cheeks from paresis of the facial muscles. The temperature is usually normal, unless there is some complication. The pupils are sluggish or con-

tracted at first, but later on they are dilated on one or both sides and are irresponsive to light. The dilated pupil usually corresponds with the side on which the pressure exists. Monoplegia or hemiplegia may occur.

The *diagnosis* from *intoxication* can be made by the dilated pupils, often unequal and irresponsive to light, by paralysis or convulsions, and by the impossibility of rousing the patient; from *opium poisoning* by the absence of contracted pupils or paralysis; from *uræmia* by the absence of œdema of the legs and of albumin in the urine. In *apoplexy* the symptoms are the same, and the differential diagnosis is impossible.

The *prognosis* is favorable with early removal of depressed bone or blood-clots which caused compression; much less favorable when compression is caused by inflammation, hydrocephalus, abscess, or tumor of the brain.

Treatment.—Remove the cause of the compression—bone, blood-clot, pus, water, foreign body, or tumor—in the earliest stages, before changes take place in the brain which may render the operation unsuccessful.

INTRACRANIAL HEMORRHAGE may be *extradural*, between the dura mater and the bone; *subdural*, between the dura mater and the surface of the brain; and *cerebral*, within the cerebral tissue.

Causes.—Apoplexy is usually the result of so-called *spontaneous* rupture of the lenticulostriate artery. *Extradural* and *subdural* hemorrhages are nearly always the result of violence.

FIG. 214.—Blood-clot (a) between the bone and the dura mater—extradural hemorrhage.

Symptoms.—*Extradural* hemorrhage in the large majority of cases is caused by rupture of the anterior or posterior branch of the middle meningeal artery as a result of violence. The patient may be merely stunned at the time of the injury, from which he apparently recovers and a few hours later becomes unconscious. Such symptoms indicate the slow escape of blood and gradual formation of a clot. Rupture of a large vessel may cause almost immediate unconsciousness and symptoms of cerebral compression. The exact location of the clot and its extension can often be determined by the focal symptoms. There may be at first spasm of the hand or arm, soon followed by spasm

of the muscles of the face or of the leg, showing that the clot has extended from the hand centre to the face or leg centre. Hemorrhage may occur on both sides of the brain, that on one side being caused by a blow and that on the other by contrecoup or by striking the pavement in falling. The temperature is at first normal or subnormal, but soon rises, reaching from 100° to 101° or 102° F. Hemorrhage into the *cerebral* tissue usually causes almost immediate unconsciousness. Hemorrhage into the *lateral ventricle*, in addition to dilatation of the pupil on the same side and monoplegia or hemiplegia of the opposite side, sometimes causes rigidity of the paralyzed limb. Interference with sensation would indicate an intracerebral hemorrhage, probably affecting the internal capsule. Hemorrhage from one of the sinuses of the brain is sudden and severe.

Prognosis.—*Extradural* and *subdural* hemorrhages promptly treated often result in recovery, while *cerebral* hemorrhages are almost invariably fatal. Small hemorrhages may be followed by absorption and recovery, but sometimes by cysts, abscess, or epilepsy.

Treatment.—In *extradural* or *subdural* hemorrhage, with evidence of interference with the brain, open the skull without delay, remove the clot, and arrest hemorrhage. The focal symptoms must determine the point at which to open the skull, and that is usually over one of the branches of the middle meningeal artery. Krönlein's method (see page 343) is convenient for locating these branches; or, roughly speaking, trephine an inch and a quarter behind and on a level with the upper border of the orbit for the anterior branch, or just below the parietal eminence on the same level for the posterior branch. *Hemorrhage from the sinuses* may be arrested by the pressure of gauze packing, the application of a lateral suture or ligature, or by a ligature around the entire circumference of the sinus.

Cerebral hemorrhage is usually beyond the reach of surgery; but where the focal symptoms indicate the location of the clot in an accessible position, its removal and arrest of hemorrhage should be attempted.

Wounds of the Brain.—The most serious wounds of the brain are punctured and gunshot wounds,—the former on account of their liability to produce infection, and the latter not only on account of the danger of infection, but from hemorrhage and the great damage inflicted on the brain tissue. Loss of brain tissue is by no means necessarily fatal—every surgeon of experience has seen such cases recover. A few wonderful cases of perforating wounds of the brain by bullets and in one case by a crowbar—the crowbar and skull may be seen in the Harvard Medical Museum—have been reported with recovery. In the majority of cases, however, gunshot wounds of the brain are fatal.

Treatment.—Wounds of the brain may be treated according to general principles governing the treatment of wounds elsewhere, making due allowance for the importance and delicacy of the organ. Should it be necessary to probe the brain, the greatest delicacy and care are required to prevent injury. In gunshot wounds with lodgement of the ball in the cranium, the location should be determined by the use of the Roentgen ray. It can then be removed if in an accessible position; otherwise it is best to leave it undisturbed.

INFLAMMATION OF THE BRAIN AND ITS MEMBRANES (MENINGITIS AND ENCEPHALITIS). — Inflammation of the dura mater is called pachymeningitis; inflammation of the arachnoid, arachnitis; inflammation of the arachnoid and pia mater together, leptomeningitis; and inflammation of the brain tissue, encephalitis. The *causes* are pyogenic bacteria, which may enter through a wound or fracture, or originate within the body as a result of an infectious disease—typhoid fever, influenza, syphilis, tuberculosis, chronic suppurative disease of the middle ear, or pyæmia. The inflammation may be limited to the dura mater. Usually all the membranes are involved, and the process extends over a considerable area of the brain surface. The usual phenomena of inflammation take place, with dilatation of the vessels, the effusion of serum and cells, and the formation of lymph or pus, which collects in the fissures or in the ventricles, or is spread over the surface of the brain, forming adhesions between the various tissues. The *symptoms* may arise suddenly during the course of some other disease, or within a few days after injury, with chill; headache, severe and general in character; intolerance of light and sound, and hyperæsthesia of the scalp; flushed face; full, rapid pulse; the temperature rises rapidly to 103°, 104°, or 105° F.; the pupils are sluggish, and at first contracted, but may become dilated or irregular later on; the bowels are constipated; the patient is sleepless and restless, with delirium, and possibly strabismus and muscular twitching. Then comes the stage of *paralysis*, with coma, involuntary evacuations, and death from the combined effects of pressure on the brain and toxæmia.

Treatment.—Keep the patient quiet in a dark room, free from all disturbance, with the head raised and an ice-bag applied to it. Keep the bowels open, but avoid excessive purgation. Look after the bladder, and use the catheter if necessary. Hydrobromate of hyoscine, large doses of bromide of potassium, chloral, or aconite may be given to limit the congestion and to produce sleep. In the stage of exudation iodide of potassium and blisters to the neck may be tried. Trephining is justifiable to relieve pressure, especially if focal symptoms appear.

The *prognosis* is bad; but should the patient recover, no mental work should be permitted for at least two or three months.

INFLAMMATION OF THE SINUSES OF THE BRAIN.—The most frequent cause is a suppurative disease of the middle ear, and the lateral sinus is that most often affected. Other causes are fractures, caries of teeth, erysipelas, pyæmia, or suppurating foci in other parts of the body. Phlebitis takes place, the endothelium becomes thickened and roughened, fibrin is deposited, and soon a thrombus is formed in the sinus, which may extend into the jugular vein and back to the torcular Herophili. Suppuration and softening may follow, and emboli may be carried to other parts of the brain, the heart, lungs, and other organs, and pyæmia is the result.

Symptoms.—There is often a history of suppurative disease of the ear or orbit. The attack may be ushered in by a chill or rigor, headache, pain in the region of the sinus, and vomiting. Often there is no chill, only mental dulness, slight headache, and possibly tenderness over the region of the sinus. If pyæmia develop, there are distinct rigors, followed by high temperature,—103° to 105°,—with profuse sweats. The temperature oscillates between great extremes. If the clot extend into the internal jugular vein, a hard, tender swelling may be felt in the neck.

Treatment.—If there is disease of the ear, open the mastoid process, and from this extend the opening in the skull and expose the lateral sinus, if necessary, to the torcular Herophili. If the jugular vein is thrombosed, ligate it below the clot and open above the ligature. Open the lateral sinus also, and clean out the infected parts of the sinus and the jugular by irrigation and curettage. Hemorrhage from the sinus may be controlled by the application of ligatures or by pressure with gauze packing.

Prognosis.—The mortality of cases operated on is about forty per cent.

ABSCESS OF THE BRAIN.—Abscess of the brain may be *single* or *multiple*.

Etiology.—About half the cases arise from suppuration of the middle ear. Other causes of abscess are fractures of the vault or base of the skull, tuberculosis, pyæmia, ulcerative endocarditis, and septic affections of the lungs or pleura, especially bronchiectasis (T. C. Claytor).

The abscess may be *extradural*, *subdural*, or in the substance of the *cerebrum* or *cerebellum*. *Traumatic abscess* is commonly situated in the frontal or parietal lobes, under the site of the injury, occasionally on the opposite side, as the result of *contrecoup*. *Tuberculosis* and *pyæmia* cause *multiple* abscess. Most abscesses occur in

the temporosphenoidal lobe, in a region included in a circle of two and one-half inches in diameter, the centre of which is one and one-fourth inches above and behind the meatus,—the "dangerous region" (Barker).

The symptoms are *general* and *focal.*

General Symptoms.—Headache, often worse on the side of the abscess; the *temperature* is usually normal or subnormal,—97° F.; occasionally a slight rise, especially at night, and chilly sensations or an acute chill may occur. The *local temperature* on the side of the abscess is usually increased. (In *extradural abscess* the general temperature is elevated,—102° to 104° F.; there is more apt to be local pain and tenderness, and sometimes œdema of the scalp.) The pulse is slow, —60, 40, or even 30 a minute. In the last stages it becomes rapid. *Respiration* is natural, slow, or of the Cheyne-Stokes variety. If there has been a discharge from the ear, it usually ceases. The patient's general condition fluctuates; for a time the symptoms may gradually improve, to be followed by a relapse. *Sensation* is not usually affected. *Anorexia* and *vomiting* are present, the mind becomes clouded, and *coma* may follow, with involuntary evacuations, ending in death. The chlorides in the urine are said to be diminished, while the phosphates are increased in amount.

Focal symptoms are the symptoms by which the part of the brain involved is determined. (See TUMORS OF THE BRAIN.)

Diagnosis.—Meningitis may be distinguished by its more acute symptoms, with elevation of temperature, delirium, rigidity of the cervical muscles, and contraction of the pupils. *Mastoid disease* follows disease of the middle ear, and is indicated by pain, swelling, and œdema in the mastoid region. *Thrombosis of the lateral sinus* is apt to give an elevated temperature, and if pyæmia coexist, there are rigors, sweating, and severe prostration, while the mind may be unaffected. The veins of the face may be swollen and hardness of the jugular vein may be detected. *Mastoid disease, thrombosis of the lateral sinus*, and *cerebral abscess* may all three exist together. A *tumor* in the brain is usually of much slower growth, the focal symptoms appear earlier, choked disk is more marked, is usually double, and tumor is not so frequently found in the temporosphenoidal lobe as abscess. There is less fluctuation of the symptoms in tumor, but a steady increase in their severity. The *prognosis* is usually unfavorable. Small abscesses may remain latent for years, or possibly disappear by absorption. Rupture into the ventricles is invariably fatal.

Treatment.—Prophylaxis in treating diseases of the ear, eye, and nose, and of wounds and fractures about the head, is of the highest

importance. *Curative Treatment.*—Open the skull over the region indicated by the focal symptoms, or, in the absence of these, in the "dangerous region" in von Bergmann's quadrangle. Often on opening the dura the brain bulges, and there is absence of pulsation. Insert a grooved director through the brain tissue in the direction of the abscess until pus flows. If none is found, do not sweep around, but withdraw the director, and insert in a new place. Having located the abscess, enlarge the opening with a hæmostat, evacuate the pus, and insert a drainage-tube, which is gradually withdrawn as the discharge diminishes. In *cerebellar* abscess make the opening below the lateral sinus. In abscess due to *disease of the middle ear*, open the mastoid antrum and cells through the "suprameatal triangle" (Macewen), a triangle formed above by the posterior root of the zygoma, in front by the upper and posterior segment of the external auditory meatus, and behind by an imaginary line, nearly vertical, uniting these two. Make the opening with chisel or gouge near this vertical line, in a direction inward and slightly forward, about one-third of an inch behind and above the centre of the meatus. The antrum is usually found at a depth of half an inch or less. Avoid the facial nerve in the aqueduct of Fallopius by keeping at a safe distance behind and above the meatus. Clean out the antrum and cells, if diseased, examine the lateral sinus, open the skull in the "dangerous region," and search for the abscess in the temporosphenoidal lobe.

Tumors of the Brain.—*Frequency and Variety.*—Starr's table of six hundred brain tumors shows about the same frequency in children and adults. Histologically the order of frequency is as follows: (1) Sarcomata, including gliomata. (2) Tuberculous tumors. (3) Cysts. (4) Carcinomata. (5) Syphilitic gummata. (6) Other varieties, such as myxomata, fibromata, osteomata, neuromata, papillomata, etc.

Sarcomata and carcinomata are more frequent between the ages of twenty and forty, while tuberculous tumors are about four times more frequent in those under twenty years of age. Starr believes that syphilitic gummata come first in order of frequency, and that they are often cured by medical treatment.

Location.—The different parts of the brain were affected in the following order of frequency: (1) The *cerebral axis*, which includes the basal ganglia and lateral ventricles, with 185 tumors. (2) The cortex of the brain, with 148. (3) The cerebellum, with 141. (4) The centrum ovale, with 86; and the remainder were multiple tumors in different regions. Of the entire 600 tumors, in only 37, or 6 per cent., was there a reasonable hope that a successful operation could be performed and the tumor removed. Over 1000 cases of brain

STARR'S TABLE OF SIX HUNDRED BRAIN TUMORS.

	Tuberculous.		Glio-matous.		Sarco-matous.		Gliosar-comatous.		Cystic.		Carcino-matous.		Gumma-tous.		Not Stated.		Total.	
	Children.	Adults.	Children.	Adults.	Children.	Adults.	Children.	Adults.	Children.	Adults.	Children.	Adults.	Children.	Adults.	Children.	Adults.	Children.	Adults.
I. CEREBRAL AXIS:																		
1. Basal ganglia and lateral ventricles	14	3	3	9	5	8	..	..	1	1	1	2	..	1	3	5	27	29
2. Corpora quadrigemina and crura cerebri	16	1	1	2	3	2	..	5	..	..	..	1	..	..	1	7	21	18
3. Pons	19	11	10	..	5	1	2	1	1	..	..	2	..	3	1	..	38	18
4. Medulla	2	..	..	1	..	..	..	..	1	..	2	..	..	..	1	..	6	1
5. Base	..	3	..	2	1	3	1	1	1	..	1	..	..	..	4	1	8	10
6. Fourth ventricle	1	..	1	..	1	1	..	..	..	..	1	2	..	..	1	1	5	4
II. CEREBELLUM	47	8	15	8	10	13	1	6	9	..	3	..	..	..	11	10	96	45
III. MULTIPLE TUMORS	34	4	..	2	3	5	..	..	2	..	..	2	1	3	3	1	43	17
IV. CORTEX CEREBRI	13	9	6	19	1	46	..	8	..	1	1	19	..	13	..	12	21	127
V. CENTRUM OVALE	6	2	1	11	5	7	1	4	15	..	1	3	1	..	5	4	35	31
	152	41	37	54	34	86	5	25	30	2	10	31	2	20	30	41	300	300

tumor studied clinically and post mortem gave about 7 per cent. as removable.

Etiology.—*Traumatism* is a frequent cause, brain tumors being about three times as frequent in males as in females, and most common between the ages of ten and forty years, the three decades of greatest activity and exposure to injury (von Bergmann). Tumors arising from traumatism are usually sarcomata or tuberculous tumors, occasionally cysts and fibromata. Other causes are actinomyces, echinococci, syphilis, tuberculosis, and cancer. Cysts usually result from the degeneration of other tumors, from the action of parasites, or from cerebral hemorrhage. Tumors arising from tuberculosis are generally multiple. Those of benign character—cysts and fibromata—are usually encapsulated, while the malignant tumors—sarcomata and tuberculous gummata—are usually non-encapsulated, and infiltrate the surrounding tissues. The effect of all tumors is mechanical, but in addition malignant tumors destroy the brain tissue by a specific action.

Symptoms.—As in abscess of the brain, the symptoms of tumor may be divided into *general* and *focal*.

General Symptoms.—1. *Headache* is present in nearly all cases. It comes on early and is general, constant, and severe. When the tumor is superficial, the pain is usually greatest just over the tumor. 2. *Tenderness* on percussion may be general or confined to the region of the tumor. 3. *Vertigo* and *vomiting*, especially in cerebellar tumors. 4. *Epileptic convulsions* occur in many cases and may be *general* or *focal*,—that is, always beginning in the same group of muscles, thus affording valuable information as to the situation of the tumor. 5. *Paresis* or *paralysis*, local or hemiplegic, may follow convulsions. 6. Choked disk is nearly always present, and is usually bilateral. If it be monocular or more marked on one side when bilateral, the tumor is likely to occupy the opposite side of the brain. The pupils are often sluggish, and may be unequally dilated or contracted, and the eye muscles may be affected, producing internal or external strabismus. 7. Somnolence, apathy, loss of mental power, and coma are often present.

Focal Symptoms.—1. *Spasms* of the muscles of the face or extremities, or epileptic convulsions always beginning in the same group of muscles, would locate the tumor in the motor centres about the fissure of Rolando. 2. *Anæsthesia*, with early involvement of the third, fifth, sixth, and seventh cranial nerves, indicates a tumor at the base of the brain or in the vicinity of the internal capsule. 3. *Aphasia* points to a lesion of the left side of the brain in right-handed persons, or to the right side in left-handed persons. 4. *Motor or*

lingual aphasia—inability to pronounce words, being no longer able to recall or control the combination of necessary muscular movements—indicates a lesion of Broca's centre, the posterior part of the third frontal convolution. (*b*) *Agraphia*—inability to write, not from paralysis, but from loss of the memory of how to make the necessary muscular movements—indicates a lesion of the posterior part of the second frontal convolution, or of a centre near Broca's convolution. It is often associated with motor (lingual) aphasia. (*c*) *Word-deafness*, or *amnesic aphasia*,—inability to recognize spoken language,—indicates a lesion in the posterior half of the first temporal convolution. (*d*) *Word-blindness*, or *alexia*,—inability to recognize printed or written words,—indicates a lesion in the angular or supramarginal gyri, and is sometimes associated with mind-blindness, mind-deafness, or apraxia, in which there is a loss of the memory of the appearance of objects, or a loss of the memory of sounds, so that neither objects nor sounds awaken intelligence or recognition in the patient. In such cases the lesion exists in the angular and supramarginal gyri or in the posterior part of the first and second temporal convolutions. 4. *Homonymous hemianopsia* is blindness in the corresponding halves of each retina; for example, *left* homonymous hemianopsia is blindness of the left half of the visual field, and therefore blindness of the *right* half of each retina, the retina being divided into two lateral halves by a vertical line. *Left* homonymous hemianopsia indicates a lesion of the *right* cuneus of the occipital lobe, or of the fibres leading therefrom to the eyes. *Wernicke's symptom:* When it is possible to make Wernicke's test it can be determined whether the tumor is located between the retina and the tubercula quadrigemina or beyond the latter. By means of an opthalmoscope light is thrown into the hemianoptic eye, and if contraction of the pupil occur when the light is concentrated on the *blind* side of the retina as well as on the *seeing* side, the lesion is beyond the tubercula quadrigemina. If no contraction of the pupil takes place unless the light is concentrated on the *seeing* half of the retina, the lesion is between the eye and the tubercula quadrigemina. 5. *Blindness* coming on rapidly would locate the tumor in the cerebellum or pons. Persistent headache, vomiting, vertigo in the recumbent as well as in the upright position, and titubation also point to the cerebellum as the seat of the tumor. 6. *Localized pain, tenderness*, local elevation of temperature, and the early appearance of spasms and aphasia render it probable that the tumor is located in the cortex or subcortical area. It should not be forgotten that, normally, the left side of the head has a slightly higher temperature than the right. 7. A tumor in the *silent areas*—the greater portion of the frontal convolutions on both sides, the temporosphenoidal on

the right and portions of the occipital lobe and cerebellum on both sides—may give rise only to general symptoms with complete absence of focal symptoms.

Diagnosis.—Abscess may be distinguished by its more rapid development, by its appearing sooner after injury, by a prolonged subnormal temperature in some cases and in others by symptoms of inflammation or suppurative disease of the ear, and by the fluctuating course of the disease. *Tumor* grows slowly and steadily and causes early focal symptoms; the *temperature* is not remarkable, and the patient may give a history of syphilis or tuberculosis. *Multiple tumors* are indicated by the implication of centres situated at a distance from one another. The *nature* of the tumor may be suspected by the history of the patient including cancer, syphilis, or tuberculosis, or injury to the head. Tuberculous tumors occur most frequently in those under twenty, in the proportion of about four to one.

Von Bergmann[1] reports the results of two hundred and seventy-five operations for intracranial tumors, one hundred and fifty-seven being merely exploratory or palliative, with a mortality from the operation of 38 per cent. The mortality from the incomplete was much higher than that from the complete operations, being 48 per cent., probably due to the extensive injury done the brain in the search for the tumor. In operations for tumors of the cerebellum the mortality has been about 65 per cent. Unless the operation is done before the destruction of important centres, blindness, epilepsy, or paralysis may remain after the removal of the tumor.

Treatment.—In some cases syphilitic gummata can be cured by the administration of iodide of potassium in large doses, continued for from one to three months, and if no improvement occur the gumma should be removed by operation. In all other varieties the only hope of cure is to remove the tumor, when accessible, at the earliest possible moment. A large opening in the skull is necessary, and may be made by an osteoplastic flap three to four inches in diameter, or the skull may be opened with a trephine and the opening enlarged by means of forceps. Examine the dura for changes in the way of thickening or adhesions. Open the dura, and if the tumor does not come into view, search for it with a grooved director; or make an incision with the knife and introduce the finger, the tumor being recognized by its density and resistance. Having found the tumor, remove it with the finger, a sharp spoon, knife, or scissors. Arrest hemorrhage, pack the cavity, if large, with iodoform gauze, and suture the flaps in place, leaving space for the gauze to project. The

[1] Die Chirurgische Behandlung von Hirnkrankheiten, 1899, p. 178.

operation may be done as a palliative measure for the relief of headache. It may be advisable, on account of severe hemorrhage, shock, or collapse, to perform the operation in two stages, the first stage ending with the opening of the skull, the second stage being completed after the lapse of from three to six days.

EPILEPSY.—Epilepsy may be *general* or *local*. The *general* form may be *local* or *focal* in the beginning of an attack; for example, it may begin with contraction of the muscles of one hand and gradually extend to the arm and other parts until the convulsion becomes general and consciousness is lost; or it may be general from the beginning. In *Jacksonian epilepsy* the spasm is limited to a certain group of muscles without loss of consciousness. The *cause* of epilepsy is in many cases unknown. In other cases it may be traced to injury of the head, as a fracture of the skull in which a splinter of bone penetrated the brain, a blood-clot formed, and was followed by an abscess, cyst, or tumor; or simply the irritation caused by the contraction of a scar in the brain substance, in the scalp, or sometimes in other parts of the body.

Treatment.—Operations for the relief of epilepsy have been disappointing. In *general* epilepsy *without* focal symptoms operation is useless except for the relief of headache. In *general* epilepsy *with* focal symptoms, or in Jacksonian epilepsy, even where no history of traumatism can be obtained, exploration is justifiable, and if no lesion can be found after opening the skull and dura mater, the cortical centre governing the muscles affected by the spasm may be excised. The centre is identified by passing a weak faradic current through the convolutions, and is excised with scissors or knife, all the gray matter down to the white substance being thoroughly removed. The paralysis which follows usually lasts for only a few weeks or months. Examine traumatic cases, after shaving the scalp, for tender or painful scars, and, if found, excise them. If this fails to give relief seek the lesion within the skull.

Surgery of the Spine.

SPINA BIFIDA.—Spina bifida, cleft spine, or hydrorrhachis, is a congenital defect, most common in the lumbar region, in which the laminæ and spinous processes of one or more vertebræ are wanting, so that a protrusion of the membranes of the cord, with or without some of the nervous structures, takes place through the opening. Sometimes the defect extends to the bodies of the vertebræ. Not infrequently other deformities coexist, as harelip or club-foot.

The *varieties* are: *Meningomyelocele*, the most common variety, in which the tumor contains fluid and a portion of the spinal cord;

syringomyelocele, or *syringomyelia*, in which the membranes and cord form the sac, the dilated central canal of the cord forming the cavity; and *spinal meningocele*, when it consists only of membranes and fluid, possibly covered by skin. *Spina bifida occulta* is simply a defect in the bone without protrusion of the membranes.

Symptoms.—At birth a fluctuating tumor, covered with skin or a transparent membrane, is observed, of the size of a walnut to that of a child's head, situated in the median line and becoming more tense when the child cries or coughs. Pressure may cause it to disappear while the fontanels become tense, and convulsions or stupor may result. The bony margins of the spinal defect can often be felt.

The *diagnosis* must be made from congenital tumors and cysts situated in this region.

Prognosis.—Death usually occurs within six months or a year, often from ulceration of the tumor with infection and the development of meningitis, or from general weakness. A few cases undergo spontaneous cure, the vertebral arches continuing to develop and the sac contracting until the defect is closed.

Treatment.—If the tumor is small and covered with healthy skin, try gentle compression, if the child bears it well, by means of a wad of cotton held in place by a bandage. One drachm of a solution of iodine, ten grains; potassium iodide, one drachm; and glycerin, one ounce, may be injected into the tumor every week or ten days, introducing the needle through healthy skin at the side or base of the swelling. Do not injure the cord or nerves, and close the puncture with collodion. *Operation* is best, and may be performed after the child is three months old. Make an elliptical incision; remove the redundant skin. Dissect the skin from the membranes, if possible, to the base of the tumor; open the membranes carefully, to avoid injury to nerves and the escape of an excessive amount of fluid. Remove excess of membranes, leaving only enough to cover in the

FIG. 215.—Spina bifida. (Wharton and Curtis.)

cord. Then unite by sutures of catgut or fine silk. The skin flaps are then united and a dressing applied. In some cases the defect can be closed with a flap of periosteum dissected from the sacrum. After operation keep the child quiet, with the lumbar region elevated, to limit the pressure of the cerebrospinal fluid against the wound. The *mortality* from the operation is about 25 per cent. The *dangers* are shock, the loss of cerebrospinal fluid, and septic infection.

INJURIES OF THE SPINE.

CONCUSSION OF THE SPINAL CORD corresponds to concussion of the brain, and is caused by blows on the spine, falls striking on the feet or buttocks, violent twists or flexions, or crushing force, often railway accidents, hence "railway spine." There is doubtless more or less rupture or laceration of the nerve-fibres as well as of the blood-vessels, with hemorrhage, so that the difference between concussion and compression is simply one of degree. Myelitis may result. The *symptoms* are shock, pallor, lowered temperature, and sometimes nausea or vomiting and temporary paralysis, followed by numbness, tingling, or other forms of paræsthesia. In the case of a young man who received a blow from a baseball bat over the lumbar spine, there was complete paralysis of motion of the lower extremities, lasting about twelve hours, after which there was complete restoration of functions and no further trouble. In "railway spine" the symptoms are genuine or imaginary, and may come on immediately or not until some time after the accident. Often the mind is affected by the shock, the fright, and the circumstances of the accident. The patient may soon recover, or the condition may become chronic, especially in females, and assume a neuræsthenic or hysterical type with general weakness of mind and body, headache, insomnia, irritability, loss of memory, eye-troubles, dyspeptic symptoms, sensory, and motor disturbances,—anæsthesia, hyperæsthesia, or paræsthesia, pains in the back or limbs of a neuralgic character, exaggeration of the reflexes, sometimes paralysis and contractures of the limbs, epileptiform attacks, and hysterical insanity. Charcot has offered as an explanation that the condition in some cases is analogous to hypnotic suggestion, the shock to the brain suggesting severe injury, the idea remaining more or less permanent.

Diagnosis.—If there is doubt as to the genuine character of the symptoms, watch the case carefully and study the patient's tendency to exaggeration. Test for fraud by the pretended use of the electric battery or the use of prisms before the eyes. *Rigidity* of the *spinal* muscles, especially if limited to one side, cannot be feigned.

Treatment.—In simple cases of concussion keep the patient quiet,

in the recumbent posture, until the symptoms disappear. The treatment of "railway spine," when it assumes the neurasthenic form, should be directed to toning up the nervous system by means of tonics, hot and cold baths, massage, out-of-door life, with agreeable occupation, or a change of surroundings. In some cases Weir Mitchell's "rest cure" will give the best results.

FRACTURE-DISLOCATIONS OF THE SPINE.—On account of the numerous strong ligaments which unite the vertebræ, a dislocation rarely occurs without fracture—hence the term "fracture-dislocation." Fracture without dislocation is more common. The vertebra nearest the head is the one spoken of as displaced. Fractures of the spine form only .33 per cent. of all fractures and are most frequent in the bodies and the arches of the cervical and dorsal vertebræ. The vertebræ most frequently fractured are the fifth and sixth cervical, the last dorsal, and the first lumbar. Most fractures occur in males during the middle period of life.

The *causes* are blows, falls, machinery and railway accidents, and especially forced flexion of the spine. There is usually displacement forward, backward, or rotary, so that the cord is crushed or compressed by the displaced portions, by the result of hemorrhage, or it may be penetrated by splinters of bone.

Symptoms.—Deformity may be shown by abnormal projection, separation, or lateral displacement of the spinous processes. In the cervical region the displaced body may be felt by the finger in the pharynx, and the head may project abnormally forward, backward, or laterally. *Mobility* may be detected between the fragments, or the spine may be rigid. *Crepitus* was detected only three or four times in one hundred and fifty cases (Courtney), and attempts to obtain it may injure the cord. *Pain* may be absent in the worst cases, but there is always *tenderness* over the fracture. The *general symptoms* are more or less paralysis of all the parts supplied by the nerves which leave the cord below the site of injury. The patellar tendon and plantar reflexes are usually present—unless the cord has been completely crushed or divided. Injuries in the cervical or dorsal region may affect the pupils. If the ciliospinal centre is irritated, there should be dilatation; if destroyed, contraction of the pupils. Injuries of the cervical cord are apt to produce priapism. Death may result immediately from injury to the phrenic nerve, or within a week or ten days from ascending myelitis; or the patient may live for several months and die from exhaustion or septicæmia due to cystitis or the formation of bed-sores. The following table of Thorburn, given in "An American Text-book of Surgery," is of use in locating the injury from the paralyzed muscles:

The fourth cervical nerve supplies . . .	The supraspinatus and infraspinatus.
The fifth cervical nerve supplies . . .	The biceps, brachialis anticus, deltoid, and supinators.
The sixth cervical nerve supplies . . .	The subscapularis, pronators, teres major, latissimus dorsi, triceps, and pectoralis major.
The seventh cervical nerve supplies . .	The extensors of the wrist.
The eighth cervical nerve supplies . .	The flexors of the wrist.
The first dorsal nerve supplies	The interossei and intrinsic muscles of the hand.

Prognosis.—The prognosis is always serious, and the gravity increases as the head is approached. Gurlt reports two hundred and seventy cases, with two hundred and seventeen deaths. Fractures above the fifth cervical vertebra are nearly always fatal. A few cases of broken neck have lived from several months to several years. Of fifty cases of fracture in the cervical region, treated at the Boston City Hospital from 1881 to 1897, five by operation, all the patients died in from a few hours to one month. (Courtney.)

SIMPLE DISLOCATION nearly always occurs in the cervical region, and is rarer than simple fracture or fracture-dislocation. Of Ashhurst's three hundred and ninety-four cases of fracture-dislocations, one hundred and twenty-four were said to be pure dislocations. The displacement may be *bilateral* or *unilateral*, *complete* or *incomplete*, *forward* or *backward*. The most common variety is the *complete bilateral forward* dislocation, the inferior articular processes of the upper vertebra passing in front of the superior articular processes of the lower vertebra, while the body projects in front of the one beneath.

Symptoms.—In *unilateral* dislocation the face is turned to the opposite side. In *bilateral* forward dislocation the head is usually thrown back, the chin raised, and the larynx prominent, with rigidity of the muscles of the neck, abnormal prominence of the spinous processes behind or of the bodies of the vertebræ in front, detected through the pharynx, and symptoms of compression of the cord. The prognosis in simple dislocation is slightly better than in fracture-dislocation, as the cord is not so likely to be injured.

Treatment.—If there are no signs of pressure on the cord or nerves, probably the safest treatment is to fix the parts by a suitable apparatus until recovery takes place. When there are symptoms of injury to the cord in *dislocation*, with or without fracture, an attempt may be made to reduce the dislocation by extension and counter-extension with manipulation; or, in *unilateral* dislocation, perform retrolateral flexion in the direction of the side towards which the face is turned by the displacement, then rotate back into place; and in

bilateral dislocation try retrolateral flexion, first on one side and then on the other (Walton). The possibility of increasing the injury or producing sudden death during the attempt must be considered.

Gradual extension may be made by putting the patient on an inclined plane with an occipitomental collar applied and attached to the head of the bed. In case of failure to remove the pressure or when it is probable that fragments of bone are pressing on the cord, perform *laminectomy* at once, or within twenty-four hours after the injury,—before degeneration begins.

Laminectomy.—Place the patient prone, or on one side with pillows to hold him in position. The prone position is dangerous from interference with respiration, especially when the cervical region is affected. Make an incision over the spinous processes with its centre over the injured vertebræ. Separate the muscles from the spinous processes and the posterior surfaces of the laminæ on each side as far as the articular processes of from three to five vertebræ. Examine the spinous processes, the articular processes, and arches for fracture or displacement. If it be possible to correct the displacement and remove the pressure, the operation need not proceed further. As the bodies are so frequently fractured, it is best, as a rule, to remove the laminæ with the spinous processes in order to examine the bodies. In the cervical region where the spinous processes are short, cut the laminæ on each side with bone-forceps close to the articular processes and remove the arches of two or more vertebræ as may be required. In the lower cervical and dorsal regions, to facilitate the operation, cut the spinous processes first and then the laminæ. Carefully examine the dura and decide whether it is necessary to open it, and examine the bodies of the vertebræ in front to see if there is a fragment of bone producing pressure. This may be done by pulling the cord gently to one side while the finger is passed in front of it and the bony surfaces examined. Remove blood-clots which may be found in the dura, and close with fine catgut; remove fragments of displaced bone and reduce dislocations or displacements. Suture the cord if severed. Harte and Stewart report a successful case. Stop bleeding by pressure and catgut ligatures. Unite the muscles and skin over a rubber or glass drainage-tube. Dress the wound and steady the spine by means of sand-bags or a gypsum cast. The mortality with operation is about 50 per cent., and without operation about 80 per cent. Some brilliant results have followed operations in the lumbar and dorsal regions, but in thirty-seven cases operated in the cervical region there were thirty deaths (S. Lloyd).

After-treatment.—Place the patient on a water-bed and guard against bed-sores, whether an operation has or has not been done, by

cleanliness, frequent changes in position, and alcohol baths. Use a sterile catheter to empty the bladder, three or four times in twenty-four hours, and enemata and cathartics for the bowels.

DISEASES OF THE SPINE.

SPINAL CURVATURE.—There are three principal pathological curvatures, according to the direction of the convexity,—namely, backward, forward, or lateral curvature, called respectively *kyphosis*, *lordosis*, and *scoliosis*.

KYPHOSIS is more frequently seen in old persons than in children, and in the dorsal region, being an exaggeration of its normal curve. The deformity varies in degree from slight exaggeration of the normal curvature to that in which the patient is bent almost double. In children it may be caused by rickets, sitting upright at too early an age without proper support or habitually with the spine bent. In adults it may be due to *occupation;* to *disease*, as osteomalacia, rheumatoid arthritis, paralysis; to general muscular weakness; or to old age. The *changes* in structure vary from a slight relaxation of the vertebral ligaments, with more or less separation of the spinous processes, to wasting or destruction of the intervertebral disks and bodies of the vertebræ. In extreme cases the viscera are compressed or displaced.

Treatment.—In the young prevent the formation of bad habits of position. Use shoulder braces and make the child sleep without pillows or with only a small pillow under the head. Develop the muscles by gymnastics and exercise in the open air. The existence of rickets of course requires proper treatment for that disease.

LORDOSIS is usually seen in the lumbar region as an exaggeration of the normal curve, often compensatory to kyphosis in the dorsal region or to congenital dislocation of the hips. It may be the result of paralysis, the presence of large abdominal tumors, or occupations.

Treatment.—When compensatory but little can be done to correct it. When due to paralysis or rickets the use of electricity, massage, and proper hygienic conditions are indicated. In some cases a plaster or leather jacket may be useful in diminishing the deformity.

SCOLIOSIS is the most common variety of spinal curvature, and consists of two or more lateral curvatures with the convexities in opposite directions, one of which is the principal curvature and the others the compensatory curvatures, which may be one or more in number. It is seen most frequently between the ages of eight and fifteen years, and in girls in the proportion of four or five to one. The *causes* are general weakness, rapid growth, prolonged ill health, any habitual one-sided position of the body, obliquity of the pelvis

from unequal length of the lower limbs, sitting at desks in school with the body inclined to one side, carrying of weights habitually on one side of the body, certain diseases, as rickets, unilateral paralysis or spasm of the muscles, empyema, sacro-iliac disease, asthma, emphysema, peritonitis, rheumatism, or rheumatoid arthritis. The most frequent variety is *right* scoliosis, seen in the upper dorsal region, with the convexity to the right, probably because most people are right-handed. The compensatory curve is in the lumbar region with the convexity to the left; sometimes a second compensatory curve is seen in the cervical region with its convexity to the left. There is often a rotation of the bodies of the vertebræ, so that the spinous processes point towards the concavity and the anterior surfaces towards the convexity of the curve. The ribs are more horizontal and widely separated on the convex side, while on the concave side they are more oblique, nearer together, and may even overlap one another.

Symptoms.—Often the first symptom which attracts attention is the discovery that one shoulder is higher than the other. The tips of the spinous processes form a curved instead of a straight line. In right scoliosis the right shoulder is higher than the left, the scapula more prominent, while the left breast and the left ilium project abnormally.

FIG. 216.—Volkmann's oblique seat for right scoliosis.

The *diagnosis* may be made from Pott's disease by the absence of marked pain, tenderness, or rigidity.

Prognosis.—Begun in the early stages, treatment will often correct the deformity.

Treatment.—A thorough system of gymnastics should be practised. Suspension by the arms from a horizontal bar, or the use of Sayre's apparatus, with an occipitomental collar for suspension, should be practised for a certain time every day. The patient may lie in a sling made of a broad strap which presses on the convexity of the curvature, while the weight of the head and shoulders on the one side and the lower part of the body on the other tend to correct the deformity. In sitting, a slanting seat may be used which is some inches higher on the side corresponding to the convexity of the lumbar curve, so that the spine may be strengthened and the curve straightened in the efforts to produce compensatory curves to the obliquity of the pelvis thus produced. Or a thicker-soled shoe may be used on the same side. Rapidly-increasing deformity may

require jackets of plaster of Paris, leather, or wood. Plaster of Paris is applied according to the method described in the treatment of Pott's disease. Schede and Weigel have invented a machine for the treatment of scoliosis. Electricity, massage, and constitutional treatment are important.

POTT'S DISEASE, SPONDYLITIS, CARIES OF THE SPINE, OR TUBERCULOSIS OF THE SPINE is a destructive disease of the bodies of the vertebræ, most frequent in the dorsal region, characterized by a peculiar deformity of the spine and a tendency to the formation of abscesses.

Etiology and Pathology.—The *predisposing causes* are: *Heredity*, a *tendency* or poor resistance to the disease being inherited; *childhood*, between the ages of three and ten years; *poverty*, with bad hygienic conditions; the *exanthemata*, "*taking cold*," and *slight injury*. The *exciting cause* is the tubercle bacillus, which falls into favorable soil, usually the spongy tissue of the body of a vertebra towards the anterior surface. It probably never begins in the intervertebral disks, but these are often included in the progress of the disease. More than one vertebra may be primarily affected at the same time. Granulation tissue forms and the vertebræ soften. *Resolution* may take place at an early stage with little or no destruction of bone. The disease may be arrested even after the destruction of more or less of the bodies of the vertebræ with the intervertebral disks, and recovery take place with the development of the granulation tissue into fibrous tissue or bone, with ankylosis. In the *most active* form of the inflammation the tubercle bacilli gain the mastery, the granulation tissue breaks down, liquefies, and forms pus. Destruction of the bodies of the vertebræ causes those above and below to come together, giving this portion of the spine a sharp concavity in front with an angular projection of the spinous processes behind when occurring in the dorsal region. A compensatory lordosis often develops in the lumbar region. When the cervical or lumbar vertebræ are attacked, the falling together of the bodies may destroy the normal curve of those regions and render them straight. The dura mater next the bodies of the vertebræ may thicken from pachymeningitis, with compression of the anterior part of the cord and motor paralysis. Paralysis is rarely caused by myelitis or pressure by bone or pus.

Symptoms.—1. *Rigidity of the spine* is one of the earliest and most constant symptoms. This rigidity is more noticeable after rest, and may disappear to some extent after exercise. The child tires easily and is less inclined to play than usual. The rigidity may be shown in many ways. If asked to look at something behind him, instead of turning the head alone, the child turns the whole trunk. When

asked to pick up something from the floor, instead of stooping by bending the spine in the usual way, he squats down, keeping the spine stiff, bending the hips and knees. He walks in a peculiar, careful manner, as if walking on eggs or on ice. When the disease is in the dorsal region, the shoulders are elevated and fixed by the contraction of the scapular muscles. When in the cervical region, torticollis may be a symptom. 2. *Pain and Tenderness.*—Pain in the region supplied by the nerves which come from the diseased parts may be one of the earliest symptoms, and is sometimes noticed before the appearance of rigidity. It may be worse at night, causing restlessness and, when severe, "night-cries." The location of the pain is most frequently in the intercostal and upper abdominal regions, where the nerves arising from the dorsal portion of the cord are distributed. In disease of the *cervical* region there may be cough, difficulty in swallowing or breathing, and a feeling of constriction about the neck, or neuralgic pains or numbness in the arms and hands. In *lumbar* disease the pain is in the lower abdomen or lower extremities, and there may be vesical and rectal irritability. *Tenderness* is shown by pressure or percussion over the affected region, by getting the patient to jump from a chair to the floor, or by laying the patient across the knees on his face and pressing the vertebræ together. 3. *Deformity.*—In some cases this is the first sign to attract attention, and may appear as a small projection from the abnormal prominence of a spinous process. This is nearly always a *kyphosis*, rarely *lateral* in direction. 4. *Abscess.*—According to J. E. Moore, abscess occurs in a large percentage of untreated cases and in 10 per cent. of those properly treated. It is more frequent proportionately in adults than in children and when the disease is in the lumbar region. While usually developing in the later stages of the disease, abscess may develop early, and may even be the first sign of the existence of the disease. The location of the abscess depends to some extent on the seat of the disease. In the *cervical disease* it may appear in the pharynx (retropharyngeal abscess) or externally behind the angle of the jaw. It may descend between the muscles and appear on the surface near the sternomastoid muscle, or it may break into the œsophagus, trachea, pleura, lung, or posterior mediastinum. In *dorsal disease* the abscess may appear as a dorsal abscess at any point in the back near the dorsal vertebræ. More frequently it descends behind the diaphragm and points in the iliocostal space, forming a *lumbar abscess;* or, entering the sheath of the psoas muscle, it appears as an *iliac* or *psoas* abscess, pointing just above Poupart's ligament near the anterior superior spinous process, or below that ligament in Scarpa's triangle

FIG. 217.—Complete ankylosis of the spine. Malposition of the head. Deformity resulting from disorganization and ankylosis of the knee-, wrist-, hip-, shoulder-, and ankle-joints.

FIG. 218.—Rigidity of the spine, muscular atrophy, and ankylosis of the ankle, knee, hip, and vertebral articulations.

FIG. 219.—Immobility of the lumbar portion of the spine due to rigidity of the lumbar muscles. Ankylosis of the right hip-joint, contraction of adductor muscles of thigh.

FIG. 220.—Deformity of spine caused by rigidity of the lumbar muscles.
(International Clinics.)

to the outer side of the femoral vessels; or it may descend lower and appear on the inner or outer side of the thigh or below the knee. In *lumbar disease* an iliac or psoas abscess may form, or the pus may appear just outside of the quadratus lumborum muscle, forming *lumbar abscess*. The pus may descend through the great sacrosciatic notch and appear beneath the gluteal muscles, or anteriorly through the obturator foramen and appear at the inner part of the thigh, or still further downward, in the ischiorectal fossa. It may even ascend and break into the pleura or the bronchi. 5. *Motor paralysis* is an occasional symptom affecting most frequently the lower extremities. Sensation is rarely affected, and the reflexes may be exaggerated. In the early stages the *temperature* and *pulse* may be very slightly changed, but after the development of abscesses there is apt to be fever, with quick pulse and other symptoms of septic absorption.

Diagnosis.—The chief points are *rigidity*, *pain*, and *tenderness*, the characteristic *gait* and *attitude* of the patient, and *deformity*. Strip the patient and examine for rigidity by placing him prone upon a table. Take hold of his ankles and lift the limbs so as to hyperextend the spine. If disease is present, the rigidity makes hyperextension impossible. In *curvatures* of the spine there is absence of rigidity, pain, and tenderness, as a rule, and the deformity is usually *lateral*. *Abscesses* originating from the kidney or vermiform appendix are recognized by the acute symptoms. Other diseases not to be mistaken are *aneurism* of the thoracic or abdominal aorta, *hysterical spine*, *rheumatism*, *neuralgia*, and *empyema*.

Prognosis.—The prognosis is serious, but it is more favorable in children than in adults, and in disease of the lumbar and cervical regions than in the dorsal region. The duration of the disease is from two to four years or longer. One-fourth of the cases sooner or later die from the disease (Moore). Death may be caused by septicæmia, amyloid disease of the liver and kidneys, rupture of abscesses into viscera, hemorrhage from erosion of a blood-vessel occasionally, or tuberculous meningitis or phthisis. Paralysis of *sensation* indicates myelitis and an unfavorable prognosis. When recovery takes place it is with a permanent deformity of the spine.

Treatment.—The indications are: 1. To obtain resolution or recovery with ankylosis. 2. To treat the various symptoms and complications as they arise. 3. To give the patient the best hygienic conditions in the way of food, air, climate, and exercise. *Fixation and rest* may be obtained by one of two methods,—namely, *confinement to bed* for a long period of time or the *use of plaster-of-Paris jackets* or *other apparatus*.

bilateral dislocation try retrolateral flexion, first on one side and then on the other (Walton). The possibility of increasing the injury or producing sudden death during the attempt must be considered.

Gradual extension may be made by putting the patient on an inclined plane with an occipitomental collar applied and attached to the head of the bed. In case of failure to remove the pressure or when it is probable that fragments of bone are pressing on the cord, perform *laminectomy* at once, or within twenty-four hours after the injury,—before degeneration begins.

Laminectomy.—Place the patient prone, or on one side with pillows to hold him in position. The prone position is dangerous from interference with respiration, especially when the cervical region is affected. Make an incision over the spinous processes with its centre over the injured vertebræ. Separate the muscles from the spinous processes and the posterior surfaces of the laminæ on each side as far as the articular processes of from three to five vertebræ. Examine the spinous processes, the articular processes, and arches for fracture or displacement. If it be possible to correct the displacement and remove the pressure, the operation need not proceed further. As the bodies are so frequently fractured, it is best, as a rule, to remove the laminæ with the spinous processes in order to examine the bodies. In the cervical region where the spinous processes are short, cut the laminæ on each side with bone-forceps close to the articular processes and remove the arches of two or more vertebræ as may be required. In the lower cervical and dorsal regions, to facilitate the operation, cut the spinous processes first and then the laminæ. Carefully examine the dura and decide whether it is necessary to open it, and examine the bodies of the vertebræ in front to see if there is a fragment of bone producing pressure. This may be done by pulling the cord gently to one side while the finger is passed in front of it and the bony surfaces examined. Remove blood-clots which may be found in the dura, and close with fine catgut; remove fragments of displaced bone and reduce dislocations or displacements. Suture the cord if severed. Harte and Stewart report a successful case. Stop bleeding by pressure and catgut ligatures. Unite the muscles and skin over a rubber or glass drainage-tube. Dress the wound and steady the spine by means of sand-bags or a gypsum cast. The mortality with operation is about 50 per cent., and without operation about 80 per cent. Some brilliant results have followed operations in the lumbar and dorsal regions, but in thirty-seven cases operated in the cervical region there were thirty deaths (S. Lloyd).

After-treatment.—Place the patient on a water-bed and guard against bed-sores, whether an operation has or has not been done, by

cleanliness, frequent changes in position, and alcohol baths. Use a sterile catheter to empty the bladder, three or four times in twenty-four hours, and enemata and cathartics for the bowels.

DISEASES OF THE SPINE.

SPINAL CURVATURE.—There are three principal pathological curvatures, according to the direction of the convexity,—namely, backward, forward, or lateral curvature, called respectively *kyphosis*, *lordosis*, and *scoliosis*.

KYPHOSIS is more frequently seen in old persons than in children, and in the dorsal region, being an exaggeration of its normal curve. The deformity varies in degree from slight exaggeration of the normal curvature to that in which the patient is bent almost double. In children it may be caused by rickets, sitting upright at too early an age without proper support or habitually with the spine bent. In adults it may be due to *occupation;* to *disease*, as osteomalacia, rheumatoid arthritis, paralysis; to general muscular weakness; or to old age. The *changes* in structure vary from a slight relaxation of the vertebral ligaments, with more or less separation of the spinous processes, to wasting or destruction of the intervertebral disks and bodies of the vertebræ. In extreme cases the viscera are compressed or displaced.

Treatment.—In the young prevent the formation of bad habits of position. Use shoulder braces and make the child sleep without pillows or with only a small pillow under the head. Develop the muscles by gymnastics and exercise in the open air. The existence of rickets of course requires proper treatment for that disease.

LORDOSIS is usually seen in the lumbar region as an exaggeration of the normal curve, often compensatory to kyphosis in the dorsal region or to congenital dislocation of the hips. It may be the result of paralysis, the presence of large abdominal tumors, or occupations.

Treatment.—When compensatory but little can be done to correct it. When due to paralysis or rickets the use of electricity, massage, and proper hygienic conditions are indicated. In some cases a plaster or leather jacket may be useful in diminishing the deformity.

SCOLIOSIS is the most common variety of spinal curvature, and consists of two or more lateral curvatures with the convexities in opposite directions, one of which is the principal curvature and the others the compensatory curvatures, which may be one or more in number. It is seen most frequently between the ages of eight and fifteen years, and in girls in the proportion of four or five to one. The *causes* are general weakness, rapid growth, prolonged ill health, any habitual one-sided position of the body, obliquity of the pelvis

of iodoform in glycerin or vaselin. These injections may be repeated at intervals of two weeks or more, as may be required.

Paraplegia and *paralysis* of the *bladder* and *rectum* often disappear spontaneously after a time. In cases in which the paralysis has lasted a year, with no tendency to improve under treatment, *laminectomy* should be performed and the compression relieved. The mortality from the operation in one hundred and twenty-eight cases was 16 per cent. (S. Lloyd).

Contraction of the psoas muscles may be overcome by extension by weight and pulley, section of the muscles, or osteotomy below the trochanter.

Chipault, Callot, and others have corrected the deformity of hunchback by *forcibly straightening* the spine. The operation should not be done until some time after the disease has been arrested. The patient is anæsthetized, placed prone, and while one assistant makes traction on the pelvis and another on the upper portion of the body under the arms, the surgeon presses upon the projecting angle of the spine until it gives way and the spine becomes straight. Do not use excessive violence, but if necessary repeat the operation in a few days. A plaster jacket is worn until ankylosis takes place in the new position. There seems to be little danger in the operation, and paraplegia may be cured by it; but the deformity is not always cured.

The *constitutional treatment* consists in giving creosote, iodide of iron, phosphates, and cod-liver oil, regular diet, nutritious and easily digested, and, most important, a change of climate to a dry, elevated region, such as may be found in certain parts of New Mexico and Arizona.

TUMORS OF THE SPINAL CORD.—Tumors of the spinal cord may arise from the cord itself or from its membranes. The most common varieties are: Gumma, syphilitic or tuberculous, sarcoma (glioma), fibroma, psammoma, carcinoma, angioma, and cyst (echinococcus).

Symptoms.—The symptoms develop slowly and are those of *irritation* followed by *compression* of the cord. There are *pain*, of a burning, shooting, or neuralgic character, in the course of the nerves affected, and a dull aching in the spine; *pain* or *anæsthesia* gradually ascending from below upward; first an exaggeration, then obliteration, of the *reflexes* from below upward. *Spasm* of the muscles of the spine may develop, with *stiffness*, *lateral curvature*, and sometimes *local tenderness* on palpation or percussion. Later, paraplegia or other paralysis may develop. There may be anæsthesia on one side with hyperæsthesia and motor paralysis on the other, and sometimes a girdle sensation. The following symptoms indicate the *situation* of the tumor: Marked pain and spasm, especially if unilateral, indi-

cate an *extradural* growth; motor and sensory impairment coming on early indicates an *intradural* growth; while dissociation of sensation—that is, loss of ability to perceive heat or cold or feel pain while tactile sense remains—indicates a tumor in the *substance* of the cord, probably in the central canal. In lateral curvature the tumor is on the side of the concavity. The tumor is always situated above the upper limb of the zone of anæsthesia. The pupils are not affected unless the tumor is situated in or above the upper dorsal region.

The *diagnosis* must be made, if possible, from irritation and compression caused by hemorrhage, bone, the products of inflammation, aneurism, transverse myelitis, or sclerosis of the spinal cord.

Treatment.—If there is a history of syphilis, give iodide of potassium in large doses. If this treatment fail, or in other varieties of tumor, perform laminectomy and remove the tumor.

SAMUEL LLOYD'S TABLE OF SPINAL TUMORS OPERATED ON.[1]

TUMORS.	Number.	Intradural.	Extradural.	Unclassified.	Intravertebral.	Extravertebral.	Cervical.	Dorsal.	Lumbar.	Sacral.	Recovery.	Improved.	No Improvement.	Death from Operation.	Subsequent Death.
Cancer	2	..	2	..	1	1	..	1	1	..	..	..	..	..	2
Abscess	2	..	2	..	..	2	..	2	..	..	..	..	..	..	2
Sarcoma	15	1	7	2	5	1	2	12	..	..	1	2	..	2	9
Myxosarcoma	1	1	..	..	..	..	..	1	..	..	..	..	1	..	..
Echinococcus	8	1	7	..	2	5	..	5	3	..	3	..	..	..	5
Myxoma	1	1	..	..	..	..	..	..	..	..	1	..	..	..	..
Connective-tissue mass	2	..	2	..	..	..	..	2	..	..	2	..	..	..	..
Unclassified	10	4	4	..	..	2	..	9	..	..	4	..	1	2	2
Lymphangioma	2	..	2	..	1	..	..	..	2	..	1	1	..	..	..
Psammoma	2	1	..	1	1	..	..	2	..	..	1	..	..	..	1
Chondrosarcoma	1	..	1	..	..	..	..	1	..	..	..	1	..	..	..
Osteosarcoma	1	..	1	..	..	1	..	1	..	..	..	..	..	..	1
Lipoma	3	1	1	..	..	1	..	..	2	1	2	..	..	..	1
Enchondroma	1	..	..	..	..	1	..	1	..	..	..	..	1	..	..
	51	10	29	3	10	14	2	37	8	1	15	4	3	4	23

This table shows the mortality in fifty-one operations to have been 8 per cent. In the twenty-three dying some time later there was generally improvement for a while. There were fifteen recoveries, or about 30 per cent.

[1] From Journal of the American Medical Association, 1901.

Surgery of the Nerves.

DISEASES OF NERVES.

NEURITIS, or inflammation of a nerve, may be acute or chronic in character. It may affect any portion of a nerve, its main trunk or its peripheral branches, and one or several nerves may be involved at the same time.

Etiology and Pathology.—The *causes* of neuritis are: Injury, a contusion or wound; certain diseases, as enteric fever, beriberi, syphilis, gout, rheumatism, or the exanthemata; the excessive use of certain medicines, as alcohol, arsenic, lead, and mercury; and exposure to cold and wet. Often no definite cause can be assigned (idiopathic neuritis).

In *acute neuritis* inflammation begins in the lymphatic sheath or perineurium, and extends to the connective tissue processes of the nerve, causing swelling, œdema, and interference with the circulation, resulting in the formation of inflammatory lymph and the softening and disintegration of the nerve tubules. Sometimes hemorrhage takes place in the nerve substance, and occasionally pus is formed. In *chronic neuritis* the tendency is to an increase of fibrous tissue in the endoneurium with *sclerosis*, causing pressure on the nerve tubules and the vasa nervorum, resulting in atrophy or complete disappearance of the white substance of Schwann. The inflammation may extend along the nerve in either direction—*ascending* or *descending* neuritis, the former being the more common.

Symptoms.—*Pain*, of an aching character, along the course of the affected nerve, constant, with exacerbations at intervals, increased by motion or pressure. Sometimes the nerve may be felt as a swollen, thick cord, tender to pressure.

Constitutional symptoms—chills, fever, and headache—sometimes occur. Tingling, hyperæsthesia, numbness and, later, anæsthesia, may be felt in the regions supplied by the *sensory* nerves, while twitching of the muscles, paresis or paralysis with muscular atrophy, may occur in the parts supplied by *motor* fibres.

The *diagnosis* is made from rheumatism by the tenderness along the course of the nerve and, later, by the sensory, motor, and trophic changes; from *neuralgia* by the constant character of the pain and the tenderness on pressure which often relieves the pain of neuralgia.

Treatment.—Secure absolute *rest;* if in a limb, by enveloping it in cotton and applying a splint. Use local applications of *heat* or *cold*, as may be most agreeable to the patient. Intense pain calls for *hypodermatic injections* of morphine, cocaine, chloroform, atropine, or of

sterilized water into the vicinity of the affected nerve or sometimes into the nerve itself. Relief may be obtained by the use of *blisters*, the *actual cautery*, or the *constant galvanic current*. For chronic neuritis use counter-irritation, the galvanic current, or in cases of anæsthesia, paralysis, or muscular atrophy, the faradic current, with massage, or *nerve-stretching*. Regulate the diet, hours of sleep, exercise, and condition of the *primæ viæ*, and treat any general disease which may exist as a pathological factor. The progress towards recovery is slow, usually requiring several months, sometimes even a year or more for complete restoration to health.

NEURALGIA, "the prayer of the nerves for pure blood," is a disease of the nerves characterized by paroxysms of severe pain in their course or distribution, without fever, and for which there is often no demonstrable pathological lesion. In some cases *sclerosis* with *obliterating arteritis* has been found. The disease may be due to changes in the cells of the spinal cord, nerve-roots, or ganglia, or to a change in the quantity or quality of the blood supplied to the nerves. It is apt to occur in those who are anæmic, neurasthenic, or debilitated, in the course or as a sequel of malaria, syphilis, rheumatism, or gout. It may be reflex in origin from a diseased tooth, when the pain is referred to sound teeth; a stone in the kidney, when the pain may be felt in the testicle or foot; and sometimes it is due to exposure to cold or to compression of a nerve by a scar, tumor, or narrowing of a foramen.

Tic douloureux, or *trifacial neuralgia*, is a severe form of neuralgia of one or all three of the branches of the fifth nerve. It occurs most frequently in those past middle life.

Diagnosis.—The diagnosis is easily made from the excruciating character of the pain, radiating along the branches of the nerve and coming on in paroxysms between which the patient may feel perfectly well. Often there is hyperæsthesia of the painful area during the paroxysms and in the intervals, so that the patient cannot bear the slightest touch.

Treatment.—After a reasonable trial of quinine, arsenic, strychnine, gelsemium, colchicum, the salicylates, mercury, and iodide of potassium, as may be indicated, and the removal of any source of irritation, such as a diseased tooth, and the effect of change of climate, if the disease persist, resort must be had to surgical treatment,—neurectasy, neurotomy, neurectomy, or removal of the Gasserian ganglion. (See OPERATIONS ON NERVES.)

Neuralgia of stumps and scars should be treated by excision of the scar and of the diseased ends of the nerves which are affected. These may be *fibromata*, or, occasionally, *neuromata*, which have developed on the ends of the nerves (see NEUROMATA). Senn has suggested

amputation of the nerve ends so as to make a flap of epineurium to cover over the end of the nerve.

INJURIES OF NERVES are more common in the upper extremities than in the lower. The nerve may be avulsed, severed, lacerated, contused, or compressed, as the result of wounds, fractures, dislocations, or the formation of callus. "Crutch palsy" is caused by contusion of the nerves in the axilla by the use of crutches. The musculospiral nerve may be paralyzed from lying long in a position to press the nerve against the bone—sometimes seen in drunkards after prolonged sleep.

Symptoms.—In *contusion* or *compression* of a nerve the symptoms are numbness, tingling, and more or less loss of motion and sensation in the part supplied by the nerve, which may be temporary; or in severe injuries the paralysis may be permanent. After complete division "Wallerian" degeneration takes place and extends in the direction of the nerve current, the white substance of Schwann is destroyed, the nuclei of the sheath multiply, and, finally, the axis cylinder is destroyed, while the muscles show the "reaction of degeneration." The degenerative process is usually complete in three or four weeks, after which there is a regeneration and often restoration of function even in nerves which have not been united by operation. If the ends have been united the regeneration takes place sooner and the function of the nerve is more likely to be restored. Certain late *nutritive* changes take place in the paralyzed parts with atrophy or contraction of the muscles, dry, glossy, or an abnormally perspiring skin, falling out of the hairs, changes in the nails, felons, and sometimes a burning pain, called by Mitchell "causalgia."

Treatment.—Reunite the divided ends of severed nerves and prevent atrophic changes in the muscles until the nerves have been restored to their integrity by the use of electricity, massage, and hot and cold douches. For the pain of causalgia apply cold water or repeated blisters over the course of the affected nerve.

OPERATIONS ON NERVES.

The principal operations on nerves are: 1. Neurectasy. 2. Nerve-suture and nerve-grafting. 3. Neurotomy, with or without avulsion. 4. Neurectomy.

NEURECTASY, OR NERVE-STRETCHING, has been done for ataxia, neuritis, neuralgia, muscular spasm, and especially for sciatica. According to Vogt, a nerve can be stretched one-twentieth of its length, yielding most at its spinal end. The beneficial effects of neurectasy are probably due to changes in its nutrition from action on its spinal origin, to rupture of some of its fibres, or to the breaking up

of adhesions in the course of the nerve. The direction in which traction is made is important: for the relief of *pain* pull away from the cord, and for the relief of *spasm* pull towards the cord.

Stretching the Sciatic Nerve.—With the patient anæsthetized and lying on his face or side, make a longitudinal incision from the gluteal fold four inches downward, midway between the tuberosity of the ischium and the great trochanter. On incising the deep fascia the biceps muscle will be exposed and the nerve will be found at its outer border just before it passes beneath the muscle, in a direction downward and inward. The nerve is hooked out by means of the finger, and the limb lifted from the table by means of it; or, if preferred, a spring balance with a hook may be used, so that the amount of force can be accurately measured.

NERVE-SUTURE AND NERVE-GRAFTING.—This may be *primary*, if done at the time of the accident or previous to degenerative changes; or *secondary*, when performed after the establishment of degenerative changes,—weeks, months, or even years subsequent to the injury.

In *secondary* suture use an Esmarch bandage in order to have a bloodless field; find the ends of the nerves and excise the bulbous enlargement, which is usually found on the proximal end, and freshen the distal end, which is usually wasted. Approximate the ends by slight stretching and suture with fine silk, using a small round needle. The suture should be passed entirely through the nerve, including all its structures. If the ends cannot be approximated without too much stretching, the gap may be bridged by means of a flap taken from one or both ends and turned down to meet the other end; or by nerve-grafting, by using a section of nerve from a freshly-amputated limb, or from a lower animal, or the spinal cord of a rabbit; or a portion of the bone may be resected (von Bergmann), in order to shorten the limb and permit approximation of the nerve ends. After closing and dressing the wound place the limb on a splint in the position which causes least tension to the nerve until union takes place. Willard reports 123 primary sutures with 119 cures and 130 secondary sutures with 80 per cent. improved (Da Costa).

NEUROTOMY WITH OR WITHOUT AVULSION.—Neurotomy is simply division of a nerve, and is rarely done alone, being usually accompanied by avulsion either of its peripheral or central portion.

NEURECTOMY is exsection of a portion of a nerve or of the entire nerve. Neurotomy and neurectomy are usually performed upon sensory or mixed nerves for the relief of neuralgia, occasionally for the relief of spasm, as in torticollis or "tic convulsif."

OPERATIONS ON SPECIAL NERVES.—*The Supra-orbital Nerve.*—Make an incision one inch long through the site of the shaved-off

eyebrow, exposing the supra-orbital notch or foramen; seize the nerve as it escapes from the foramen, separate it from its vessels, divide it, and avulse the distal portion by rolling the nerve around the blades of the forceps.

The Superior Maxillary Division of the Fifth Nerve.—Expose the infra-orbital foramen by an incision about one and one-half inches long, just below the lower border of the orbit. Find the nerve as it emerges from the foramen deeply situated beneath the origin of the levator labii superioris muscle, and tie a silk ligature around it. Raise the periosteum covering the edge and floor of the orbit by means of a thin retractor, cut away with a gouge the bony margin above the foramen, drag the nerve into the orbit, divide it as far back as possible with blunt-pointed scissors, and then avulse it with its peripheral branches.

Removal of Meckel's Ganglion with the Second Division of the Fifth Nerve.—Meckel's ganglion is situated in the sphenomaxillary fossa just below the superior maxillary nerve, to which it is attached by its sensory roots. Make an incision as just described for the superior maxillary nerve, and if more room is required, add a vertical incision from the middle of the first downward towards the upper lip, but do not open the cavity of the mouth. Separate the nerve from its vessels, secure it with a silk ligature, and divide it distal to the ligature. Open the anterior wall of the antrum by means of a gouge, including the floor of the infra-orbital canal, so that the nerve can be drawn into the antrum. Guided by the nerve, the posterior wall of the antrum is opened in a similar manner, being careful not to injure the internal maxillary artery in the sphenomaxillary fossa. Trace the nerve back to its point of escape from the foramen rotundum, where it and the Vidian nerve just below are divided with curved, blunt-pointed scissors. By gentle traction the nerve is withdrawn, and Meckel's ganglion usually comes with it. The peripheral portion of the nerve is then avulsed in the usual way. Hemorrhage is controlled by packing with strips of iodoform gauze, which may be removed after twenty-four hours and the wound closed by sutures.

The Inferior Dental Nerve.—This may be exposed by an *external* or *internal* incision. *External incision:* Make a two-inch incision along the lower border of the jaw from a little behind the angle to the notch for the facial artery. Expose the angle of the bone, detach the insertion of the masseter muscle, and open the bone with a trephine or chisel an inch and a quarter above the angle, about the centre of the ramus, exposing the nerve in the inferior dental canal. Hook it out and resect or divide, and avulse the peripheral portion. *Internal incision:* Hold the mouth open by a gag on the opposite side; make

an incision through the mucous membrane along the anterior border of the ramus of the lower jaw and detach it from the inner side, insert the finger between the internal pterygoid muscle and the ramus and find the sharp projection at the opening of the inferior dental foramen. Catch the nerve just before it enters the foramen, on a blunt hook, avoiding the internal lateral ligament and inferior dental artery, draw down and divide or resect it.

Removal of the Gasserian Ganglion.—The *Hartley-Krause* method is the best. The eye of the affected side may be protected by uniting the lids for three or four days by two or three fine sutures. Shave the entire scalp and thoroughly disinfect it. Make a horseshoe-shaped osteoplastic flap, beginning at a point about one inch behind the external angular process of the frontal bone, cutting upward and around to a point just in front of the ear. The vertical and horizontal diameters of the flap are about three inches at the widest part, the base being not so wide. Divide the bone along the same incision by means of a chisel, saw, or surgical engine. Use a hook or elevator to pry out the bone at the top until it breaks across its base or neck, and turn it back as on a hinge. If the middle meningeal artery is ruptured, secure it by ligature or packing. Cut off any sharp fragment, or enlarge the opening in the bone towards the base of the skull by means of bone-forceps. Do not open the dura mater, but separate it gently from the floor of the middle fossa until the third and second divisions of the fifth nerve are seen converging backward from the foramen ovale and foramen rotundum respectively. The ganglion is situated at the point of convergence of these two nerves on the anterior surface of the petrous portion of the temporal bone, between the periosteum and dura mater, or between two layers of dura mater. Raise the brain gently by means of a broad retractor. Seize the roots behind the ganglion by means of catch forceps, cut the second and third divisions close to their foramina of exit; make gentle traction or rotation of the forceps and avulse the ganglion by the roots. Be careful not to wound the cavernous sinus or attempt to remove the first division of the fifth nerve. The greatest difficulty during the operation is caused by hemorrhage, which must be controlled by packing. Sometimes it is necessary to do the operation in two stages, leaving the packing in for two or three days, then reopening the wound and completing the operation. Pack the wound lightly with iodoform gauze and close it, leaving sufficient space for removal of the gauze, which may be done at the end of twenty-four or forty-eight hours. An electric light with a reflector is of great assistance in the operation. The mortality of the operation is from 10 to 20 per cent.

Abbe's Operation.—Instead of removing the Gasserian ganglion, Robert Abbe advises the following operation: Make a vertical incision through the scalp and temporal muscle just above the middle of the zygoma, retract the muscle, and make an opening in the skull one inch and a half in diameter. Separate the dura mater from the bone until the second and third branches of the fifth nerve are exposed at their entrance into the foramen rotundum and foramen ovale. Seize the nerves with forceps, divide them at their foramina, and avulse them from the Gasserian ganglion. Arrest hemorrhage by packing for a while, and then place a very thin piece of sterilized gutta percha tissue, about one and one-fourth inches long by about three-fourths of an inch in breadth, over the foramina, let the dura mater fall into place over it, and close the wound.

The Seventh Nerve.—Expose the nerve at its point of exit from the stylomastoid foramen by a two-and-a-half inch incision behind the ear, extending from the level of the external auditory meatus downward to the angle of the jaw. Expose the posterior border of the parotid gland, draw it forward and bring into view the aponeurosis of the sternocleidomastoid muscle. The nerve is found between these two at a depth of one to one and a half inches in front of the fascia covering the prevertebral muscles, as it passes from its foramen to the ramus of the jaw. The nerve is caught up on a hook and stretched or divided; if divided, facial paralysis results. It may also be exposed by an incision in front of the ear, by finding one of the principal branches in the parotid gland and tracing it back to the main trunk.

The Spinal Accessory Nerve and Cervical Plexus.—Make an incision along the anterior border of the sternomastoid muscle, with its centre opposite the hyoid bone. Draw the muscle outward and expose the nerve as it enters the muscle on its under side. Or make a two-inch incision about the middle of the posterior border of the sternomastoid muscle and expose the nerve as it passes from the posterior border of that muscle downward and backward to the trapezius. The branches of the *cervical plexus* are exposed by the same incision and may be recognized by their course upward and downward from behind the sternomastoid muscle.

The musculospiral nerve is best exposed by a two-inch incision over the space between the biceps and supinator longus muscles.

The external popliteal or *peroneal nerve* may be exposed as it winds around the neck of the fibula by an incision two inches long from the head of the fibula downward, or by an incision along the inner border of the tendon of the biceps just above its insertion.

The other principal nerves of the extremities can usually be exposed by the incisions made for ligating the corresponding arteries.

CHAPTER VII.

SURGERY OF THE RESPIRATORY ORGANS.

THE NOSE.

RESTORATION OF THE NOSE.—The *Indian method* is performed as follows: First ascertain the size of the flap necessary by cutting out a paper pattern, taking a normal nose of suitable size as a standard. This pattern is somewhat pear-shaped with a projection at the large end from which the columna of the nose is to be made. Dissect a flap the shape of this pattern, but one-third larger in order to allow for shrinkage, from the forehead of the patient, leaving it attached by a pedicle which contains the angular arteries at the root of the nose. Turn the flap into position and attach by fine sutures to the surface which has already been freshened and prepared for its reception; the wings and nostrils are formed by turning the lateral part inward, and the septum by stitching the projection already mentioned to the upper lip. When the nasal bones are deficient, use Koenig's method of dissecting up with the flap a thin layer of bone which is separated by means of a sharp chisel. The defect in the forehead is closed as far as possible by dissecting up the edges and introducing sutures, leaving the remainder to heal by granulation; or, skin-grafting may be used. The *Italian* or *Tagliacotian* method, named from Tagliacozzi, is performed in the same way as the method already described, except that the flap of skin is obtained from the arm or finger of the patient.

FOREIGN BODIES in the nose are seen most frequently in children and may consist of pebbles, beans, peas, or sometimes maggots. In young children the first *symptom* may be the occurrence of a mucopurulent discharge or of hemorrhage, when an examination will reveal the presence of the foreign bodies.

Treatment.—When possible, remove the body from the front with forceps or a tenaculum; or blow it out by inserting the nozzle of a Politzer bag into the unobstructed nostril and inflate the pharynx while the mouth is kept shut; or push it through the nose into the pharynx. For the removal of the larvæ of insects use an injection of equal parts of chloroform and water.

EPISTAXIS, OR HEMORRHAGE FROM THE NOSE, is sometimes a very annoying and may be a serious symptom.

Causes.—The source of the blood may be ulceration; traumatism, producing abrasions; *blows* upon the nose or head, with or without fracture; *concussion*, caused by heavy explosions; *change from a denser to a rarer* atmosphere; sudden efforts, such as coughing or sneezing; *congestion* of the *blood-vessels*, as in apoplexy or a plethoric habit; *certain diseases*, as typhoid fever, scurvy, purpura, and diseases of the liver, heart, and kidneys. It is sometimes vicarious of suppressed menstruation, urination, or perspiration. Often the cause is not apparent. The amount of blood varies from a few drops to enough to endanger the life of the patient, and the bleeding may continue for from a few minutes to several days. It usually comes from one nostril, but may come from both, and escapes through the anterior nares, except when the patient lies down, when it may be swallowed or get into the larynx, whence it may be vomited or coughed up.

Treatment.—Any cause for the hemorrhage which can be discovered should if possible be removed. If the hemorrhage is slight, such remedies as pressure on the sides of the nose with the thumb and finger, the application of cold to the back of the neck, and the use of astringents, ice-water, hot water, alum, tannin, cocaine, antipyrin, or adrenalin as a nasal douche may be used. The patient's head should be kept elevated. If these methods fail, or in severe cases, without wasting time in the trial of uncertain methods, the nasal cavities should be tamponed. This may be done by means of Bellocq's cannula or a male catheter, or, better still, *Roberts's method.* Roberts attaches a sponge to one end of a silk ligature and pushes it back through the nose until it reaches the posterior opening. Similar sponges or pads with a hole in the middle are successively threaded on the ligature and pushed backward until the entire cavity is filled.

Empyema of the Bony Sinuses.—The *causes* of empyema are traumatism; carious teeth (in the maxillary sinus); the entrance of foreign bodies, as bullets, splinters, or insects; syphilis or tuberculosis; but the most common cause is the extension of infection from the mucous membrane of the nose following rhinitis, especially during an attack of influenza.

Symptoms.—Empyema of the *maxillary antrum* is indicated by infraorbital pain, tenderness, and sometimes œdema and swelling. The flow of pus is not continuous, but intermittent, often occurring when the head is bent forward. Examination shows the pus escaping from the middle meatus. The patient often complains of an offensive odor which is perceived at times. Transillumination by means of an electric light in the mouth may show opacity of the affected antrum. When the *frontal sinus* and *anterior ethmoidal cells* are affected the pain,

tenderness, œdema, and swelling are felt under the superciliary ridge, and there may be congestion of the conjunctiva and œdema around the eye. The flow of pus is continuous and not intermittent as in maxillary abscess. Examination of the nose shows the pus escaping from the *middle* meatus, a little in front of and above the opening of the maxillary antrum. When the *sphenoidal sinus* and *posterior ethmoidal* cells are affected, the pus escapes above the middle turbinated bone in the *superior* meatus of the nose, and examination with the probe may reveal the presence of bare bone.

Treatment.—Abscess of the *antrum of Highmore* may be first treated by irrigation through the natural opening in the nose with salt or borate of sodium solution. If this fail to cure, establish free drainage by extracting a bicuspid or molar tooth, if diseased, and opening into the antrum through the socket by means of a drill or trocar. If the teeth are sound, open the antrum just beneath the malar process above the root of the second bicuspid tooth by means of a drill or trocar. Put in a small metallic drainage tube and irrigate daily with solution of boracic acid or bichloride, followed by the use of sterile water. In chronic cases it may be necessary to curette the interior of the abscess cavity. In abscess of the *frontal sinus* enlarge the infundibulum by the removal of the anterior portion of the middle turbinated bone, or, better, open the sinus externally just above the superciliary ridge. Make a transverse or vertical incision through the skin and fascia and open the bone by means of a chisel or gouge. A drainage-tube should be introduced through the infundibulum and the cavity irrigated and drained through this and through the external wound. This operation also gives access to the anterior ethmoidal cells. Abscess of the *sphenoidal sinus* and of the *posterior ethmoidal cells* may be drained by enlarging the natural openings in the superior meatus of the nose by means of a trocar or trephine, removing if necessary the middle turbinated bone in order to give room. Great care is necessary, in operations on the sphenoid and ethmoid bones, to prevent penetration into the cavity of the skull and infection or injury to the brain or its membranes.

THE LARYNX AND TRACHEA.

FRACTURE OF THE LARYNX is not a frequent injury, and is usually the result of blows or violent grasps upon the throat. The parts usually affected are the thyroid and cricoid cartilages. The *symptoms* are shock, pain, dyspnœa, rapid swelling of the neck, difficulty in speaking or swallowing, cough, and expectoration of bloody mucus. Emphysema and œdema of the glottis may occur.

Prognosis.—Of twenty-seven cases reported by Hunt, ten recovered

and seventeen died (Wharton and Curtis). The prognosis is most serious in fracture of the cricoid cartilage.

Treatment.—Put the patient to bed and apply soothing applications. If there are signs of obstruction, with embarrassed respiration, put the finger in the larynx and attempt to correct the deformity. Failing in this, perform intubation or tracheotomy. In some cases it is best to expose the fragments by an incision and suture them in place.

Foreign Bodies in the Air-Passages.—A common accident, especially in children, is the lodgement of a foreign body in the larynx, trachea, or bronchi. These bodies usually enter during a sudden inspiratory effort, as in laughing, coughing, vomiting, or strangling, and may consist of food, especially meat, grains of corn, beans, beads, pins, buttons, coins, pencils, false teeth, and occasionally pus or blood. The body may lodge in the larynx, or it may pass into one of the bronchi, especially the right, and lodge in one of its divisions, to be followed by inflammation, abscess, or gangrene. Sometimes the larynx is completely occluded, producing death in a few minutes, as in three cases in the writer's experience, in which a portion of meat in two cases and a collar-button in the other were drawn into the larynx.

Symptoms.—The first symptoms are interference with respiration, a feeling of suffocation with spasm of the larynx, and possibly cough. If the body is large enough, cyanosis of the face and agonizing dyspnœa result. If it enter the trachea and is movable, it may be heard on auscultation over the trachea, moving up and down during respiration or coughing, accompanied by wheezing and râles. If the body is movable, the greatest distress is usually in expiration, when it is thrown against the glottis. If the body lodge in a bronchus or one of its divisions, auscultation may reveal a murmur or diminished respiratory sounds, or, later on, a circumscribed solidification with dulness on percussion. Foreign bodies have been known to remain in the lung for several years and then be expelled during a fit of coughing.

Treatment.—Put the finger into the larynx and remove the foreign body if possible, taking care not to press it in still more firmly. Invert the patient, shake, and slap him on the back and chest; and if this fail, perform tracheotomy at once. When the symptoms are not urgent, make a laryngoscopic examination, when the body may possibly be seen and removed with forceps.

If the body is loose in the trachea or bronchus and repeated efforts by inversion and coughing have failed to expel it, perform tracheotomy before the onset of inflammation. Usually on opening

the trachea the foreign body will be expelled through the opening. If the body be impacted and fail to escape, it may be gently searched for by tracheotomy forceps, and, if not found, a tube should be worn for a while, in the hope that the body may later on be loosened and expelled. The tracheotomy wound may be closed after the removal of the body, provided inflammation has not occurred; otherwise a tube should be worn until the inflammation has subsided. If impacted in a bronchus or one of its divisions, it may be removed by an expert through an endoscope introduced through the larynx, or by an operation through the back, resecting the ribs from the fourth to the eighth next to the spinal column on the affected side.

ŒDEMA OF THE GLOTTIS is the most dangerous complication of laryngitis, and is due to infiltration with serum or inflammatory products of the loose connective tissue beneath the mucous membrane of the larynx, causing a rapid swelling which, if not soon relieved, is apt to prove fatal by asphyxia. It is most frequently the result of injuries, as burns or wounds about the mouth, fractures of the larynx, the inhalation of steam, but sometimes follows infection in the course of scarlet fever, diphtheria, erysipelas, measles, and syphilis, or occurs as a complication of Bright's disease.

The *symptoms* come on very rapidly, with cough, difficulty of breathing and swallowing, and partial or complete loss of the voice. There is cyanosis, with protrusion of the eyeballs, and the patient makes frantic efforts to breathe. The swelling can usually be felt with the finger and seen with the aid of the laryngoscope.

Treatment.—Cocainize the larynx and scarify it freely with a sharp-pointed bistoury. This may be done by the sense of touch, using the left forefinger as a guide to the swollen parts, but it is better to perform the operation with the aid of a laryngoscope. If this fail to give relief, perform tracheotomy.

OPERATIONS ON THE LARYNX AND TRACHEA.—*Intubation of the larynx*, or *O'Dwyer's operation*, consists in the introduction of a metallic tube through the mouth into the larynx, where it remains until the obstruction for which it was introduced has been removed.

The Operation of Intubation.—The proper sized tube is selected and a strong silk thread about two feet in length is passed through the opening in the collar of the tube and tied in a loop. This is for the purpose of withdrawing the tube should it slip into the œsophagus. The nurse holds the child in her lap in a sitting position with its arms bound to its body by a sheet wrapped around it and with its head resting against her shoulder, while an assistant behind steadies the child's head with both hands. The gag is placed in the left side of the mouth, in charge of the assistant who holds the head steady.

The surgeon seats himself in front of the patient with the introducer firmly attached to the obturator, over which the tube is fitted and tested as to its facility of detachment from the obturator. With the instrument held in the right hand the surgeon introduces the left forefinger into the pharynx, feels for the epiglottis, and hooks it forward. The tube is then introduced by the right hand hugging the root of the tongue, the tip of the tube being guided into the larynx by means of the left forefinger. The tube is gently but quickly pushed home by raising the handle of the introducer, the button on the handle is pressed, and the receiver with the obturator withdrawn, in the mean time keeping the left forefinger on the head of the tube to prevent its being withdrawn with the obturator. If the end of the tube project too far it can be pressed down by the finger. The loop of thread is cut and withdrawn, unless it is decided to allow it to remain so that the tube may be easily removed in case of necessity.

Intubation may be performed with the child in the recumbent position, but is more difficult. If the tube be properly introduced, immediate relief of the cyanosis and dyspnœa is given and there is usually a sharp attack of coughing, which may expel the tube. If so it should be replaced by one slightly larger.

Removal of the tube is done by placing the patient in the same position as for introduction. The *extractor* is introduced, guided by the left forefinger until the point enters the tube. Then by pressing the spring in the handle the blades are separated, holding the tube firmly while it is withdrawn.

Intubation Compared with Tracheotomy.—The advantages of *intubation* are: Absence of cutting operation, the operation is more quickly performed, and the short time necessary to wear the intubation tube. The disadvantages are: The danger of detaching false membrane in front of the tube and arresting respiration, and the difficulty of feeding the patient afterwards. *Intubation* is preferred in diphtheritic laryngitis and in cicatricial stenosis as a result of wounds or disease, in which it acts also as a dilator. *Tracheotomy* is preferred in stenosis from malignant growths, in œdema glottidis, and in some cases of intense swelling with a high grade of inflammation of the pharynx or larynx.

Laryngotomy may be performed by an incision through the cricothyroid membrane, or by dividing the thyroid cartilage in front. The former is performed as follows: Place the patient in the recumbent position, with the shoulders elevated and the head thrown back, in order to make the neck prominent. Locate the cricoid cartilage, and make a longitudinal incision in the median line, one inch or an

inch and a half long, with its centre at the upper border of this cartilage, exposing the cricoid cartilage and the cricothyroid membrane. Separate the edges of the wound and divide the cricothyroid membrane transversely for about one-half an inch. When haste is necessary, the knife may be plunged at one stroke through skin, fascia, and cricothyroid membrane. This operation is usually performed in adults for œdema glottidis, the impaction of foreign bodies in the larynx, or to administer an anæsthetic through the trachea. The tube should not be worn too long, lest it cause necrosis of the cartilage and loss of voice.

Thyrotomy is performed, after making a preliminary tracheotomy, by dividing the thyroid cartilage and cricothyroid membrane through the median line, if possible leaving the thyroid cartilage united at the upper part.

Laryngectomy.—Excision of the larynx may be partial or complete, and is a serious operation. It is performed for malignant growths, tuberculosis, and necrosis of the larynx. Tracheotomy should be performed a week before the operation, and the patient accustomed to wearing a tube. After the usual preparations, make a long incision over the larynx, and separate the soft tissues from the cartilages on either side. Divide the isthmus of the thyroid gland and, if necessary, ligate. Divide the thyroid cartilage in the median line, examine the interior of the larynx, and decide whether a partial or complete excision must be made. If *complete* excision is necessary, divide the trachea at a point well below the growth, and secure its upper end to the skin by sutures. If preliminary tracheotomy have been performed, introduce a tracheotomy tube at this point, and give the chloroform subsequently through the trachea. Detach the larynx from the œsophagus by blunt dissection and the use of the knife and scissors, keeping close to the cartilages; divide the thyrohyoid membrane and ligaments, and separate the epiglottis and the remaining attachments of the larynx. The four thyroid arteries must be ligated. Suture the anterior wall of the

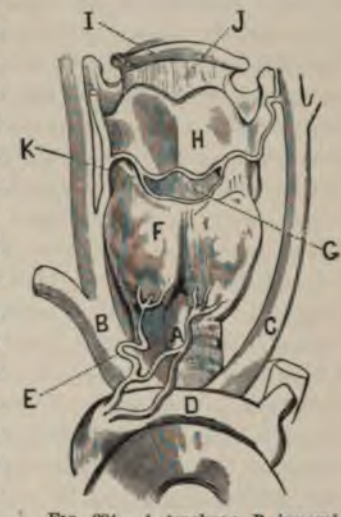

FIG. 224.—*A*, trachea; *B*, innominate artery; *C*, left primitive carotid artery; *D*, transverse vein; *E*, thyroid plexus of veins; *F*, thyroid body; *G*, cricothyroid membrane; *H*, thyroid cartilage membrane; *I*, hyoid bone; *J*, thyrohyoid membrane; *K*, cricothyroid arteries.

œsophagus to the tissues just below the hyoid bone, stop all hemorrhage, close the external wound, dress, and put the patient to bed. In *partial* laryngotomy only one side of the larynx is removed, or as much of it as may be diseased. The epiglottis should be left, unless involved in the disease. An artificial larynx, rendering speech possible, may be fitted to the trachea, provided the cut end of the trachea has not been attached to the skin nor the wall of the œsophagus to the hyoid bone. Death may be caused by shock or hemorrhage during or immediately after the operation, or later by infectious pneumonia from the passage of diseased matter into the lung, or by recurrence of the disease.

Tracheotomy.—The trachea may be opened above or below the isthmus of the thyroid gland,—high or low tracheotomy. Often it is necessary to divide the isthmus of the gland. Place the patient in the dorsal position, with a pillow under the shoulders, in order to make the neck prominent, and have an assistant hold the head steady. In urgent cases do not lose time by giving an anæsthetic. The surgeon stands on the side which is most convenient, and makes an incision in the median line of the neck from the cricoid cartilage downward one and a half to two inches, cutting through the skin and fascia, and separating the borders of the sternohyoid and sternothyroid muscles until the isthmus of the thyroid gland is exposed. Avoid any large veins which may appear, or ligate and divide them, remembering the occasional existence of a thyroidea ima artery, or the origin of the left carotid artery from the innominate. Push the isthmus of the thyroid, which usually lies on the second and third rings of the trachea, downward or upward, or divide the isthmus between two ligatures. Arrest all hemorrhage, except moderate venous oozing, which may be neglected, as it will usually cease as the trachea is opened. Open the trachea by a longitudinal incision exactly in the median line and retract the edges of the wound with tenacula until the tracheotomy tube can be introduced. As soon as the trachea is opened there is usually a gush of air, and membrane, blood, or a foreign body may be expelled. Occasionally there is sudden arrest of respiration, requiring artificial respiration while the wound in the trachea is kept open. As soon as respiration becomes easy put in the tracheotomy tube and secure it with tapes. If no tracheotomy tube is at hand, stitch the sides of the tracheal wound to the skin of the neck.

After-treatment.—Keep the patient in a room of equable temperature, warm and comfortable, and not too dry. Remove the *inner* tube about every three hours, cleanse in a solution of soda, and replace. Remove the *outer* tube and cleanse or exchange it once in

forty-eight hours. This should be done by the surgeon. Look out for ulceration of the trachea and leave the tube out as soon as practicable.

THE THYROID GLAND.

Inflammation of the thyroid gland, or THYROIDITIS, is occasionally seen as a result of typhoid fever, tuberculosis, or other infectious diseases, or from injury to an already diseased gland, as during the course of goitre, and may end in resolution or in suppuration. The usual *symptoms* of inflammation are seen and the *treatment* should be conducted on general principles.

GOITRE.—Goitre, from the Latin *guttur*, the throat, also known as bronchocele or struma, is a chronic enlargement of the thyroid gland.

Etiology and Pathology.—It occurs most frequently in females from nine to fourteen years of age and may affect the entire gland or only one side—usually the right. It occurs in all countries, but is more common in certain mountainous countries of Asia and Europe, especially Switzerland. The essential cause is not certainly known. Kocher and Tavel have shown that it is caused in many cases by certain drinking-waters, and that such waters contain more micro-organisms than others which do not produce goitre. Lime and magnesia salts in the water seem to be the cause in some cases. Fibromyomata of the uterus, carrying burdens on the head, or occupations requiring bending of the neck, are given as predisposing causes.

The *varieties* are: The *parenchymatous* or *hypertrophic*, in which there is a general hyperplasia of all the tissue elements with enlargement of the gland. The *follicular* or *cystic*, in which the growth affects principally the glandular elements, and the follicles and lymph spaces are filled up with colloid material, or there is an overgrowth of glandular epithelium. Excessive development of the glandular element, and especially of its contents, may lead to the development of cysts—*cystic goitre*, the most common variety. The *fibrous* or *interstitial* goitre is characterized by the excessive formation of fibrous tissue, giving a firm, nodulated growth. The *vascular* form is known by the excessive development of blood-vessels, chiefly veins, resembling a cavernous angioma. True tumors may develop in the thyroid, as adenoma, fibroma, carcinoma, and sarcoma. Amyloid degeneration, or calcification, may take place. Transient enlargement of the thyroid has been noticed in some women during each menstrual period or pregnancy.

Symptoms.—Goitre often begins about puberty, during pregnancy, or some uterine disturbance, with no symptoms besides the enlargement of the gland, unless pressure interferes with important parts.

A smooth, painless, bilobed swelling is seen in the lower part of the front of the neck, attached to the trachea, as it rises and falls with that organ during deglutition. The skin is unattached, but the veins over the tumor are often found enlarged. A *vascular* goitre may give a murmur on auscultation, occasionally pulsation, and is compressible. Goitres vary in size from a scarcely perceptible enlargement of the gland to an enormous mass which may cover the neck and overhang the chest. Pressure on the trachea, œsophagus, recurrent laryngeal, phrenic, or sympathetic nerves, vessels of the

FIG. 225.—Cystic goitre.

neck, or brachial plexus may cause dyspnœa, dysphagia, alteration of voice, hiccough, interference with the action of the pupil, congestion of the face, or pain in the upper extremity.

Prognosis.—On the whole the prognosis is favorable. The danger arises from respiratory disturbances due to pressure from growth in certain directions, or from hemorrhage into the gland.

Treatment.—In the young, removal to another locality with change of water will often effect a cure. Goitre has been known to disappear after an acute febrile disease. Iodine, iodoform, thyroid gland, thymus gland (from sheep), and electricity have all been tried with variable success. Iodine is used internally and by hypodermic injection into the gland, or as an ointment (red iodide of mercury)

rubbed daily into the skin over the gland. Iodoform one part, ether and olive oil each seven parts, injected into the tumor every three to five days in quantities of fifteen to sixty minims, kept up for several months, has given good results (Mosetig-Moorhof). The only reliable treatment, especially in the *cystic* and *fibrous* varieties, is to remove the greater part of the gland, leaving at least one-fourth or one-fifth, lest tetany or cachexia strumipriva (myxœdema) result. The operation, as performed by Kocher, of Bern, who has operated on over sixteen hundred cases, is preferably done under cocaine or eucaine, making a curved incision across the neck with the convexity below. The capsule is then incised and the cyst or tumor shelled out. If there is no capsule the gland must be carefully dissected away, using many hæmostats to prevent bleeding, and the greatest care to prevent injury of the recurrent laryngeal nerve.

The mortality of thyroidectomy for goitre should not be more than 1 per cent., the greatest danger during the operation being hemorrhage, and afterwards *tetany* or *cachexia strumipriva*, unless a portion of the gland has been left.

EXOPHTHALMIC GOITRE, Graves's or Basedow's disease, is a disease of the thyroid gland in connection with rapid pulse or prominent eyeballs, or both. This disease is often associated with nervous symptoms, such as tremor, hysteria, and insomnia. There may be dyspnœa, polyuria, and a systolic heart murmur. Von Graefe's symptom, seen in many cases, is brought out by telling the patient to look up and then down, when the white sclerotic is seen below the upper lids as the latter pause before following the downward movement of the eyeballs.

Etiology.—The cause of the disease is unknown, but it is thought to be due to the toxic action of some product normally modified by the thyroid gland, and which exerts a special action on the sympathetic nervous system.

Treatment.—Thyroid extract is usually contraindicated, though suprarenal extract may be given with advantage. Park recommends thyroid extract and sodium phosphate in gradually increasing doses. Digitalis may be useful to quiet the rapid heart. The *surgical* treatment is partial *thyroidectomy*, *ligation* of the *thyroid arteries*, or *excision* of the *sympathetic cervical ganglia* on one or both sides. Of one hundred and ninety thyroidectomies about 65 per cent. were cured or relieved, and 17 per cent. died (Starr). Of fifty-six cases treated by ligation of the thyroid arteries there was no mortality from the operation, and fifty-one of the cases were cured or relieved (Kocher and Rydygier).

To remove the sympathetic ganglia, make an incision from the

tip of the mastoid to the acromion process, posterior to the sterno-mastoid muscle. Draw the great vessels forward and expose the superior cervical ganglion lying on the rectus capitis anticus major

FIG. 226.—Exophthalmic goitre. (International Clinics.)

muscle, opposite the transverse processes of the second, third, and fourth cervical vertebræ. Divide all the branches except those leading to the middle cervical ganglion, which are used as guides in finding this ganglion, that is located opposite the sixth cervical vertebra. The inferior ganglion lies between the base of the transverse process of the seventh cervical vertebra and the neck of the first rib. General anæsthetics are especially dangerous in exophthalmic goitre, hence they should be given with the greatest care.

THE PLEURA AND LUNGS.

INJURIES of the lungs and pleura may be contusions or closed or open wounds.

Contusion of the lung or pleura may be caused by blows on the chest, which may or may not fracture the ribs, but may be severe enough to rupture the lung or pericardium. *Closed wounds* are most

frequently the result of puncture by fractured ribs. *Open wounds* are usually caused by knives and bullets.

Symptoms.—If the lung is wounded, there is *hemorrhage*, which is shown in the expectoration, cough, râles on auscultation, or by the escape of blood from the wound. Later hæmothorax or empyema may occur, or abscess or gangrene of the lung. *Pneumothorax* with collapse of the lung will occur if the wound connect the pleural cavity with the outer air, and air may be heard to enter the chest with a hissing sound during respiration,—*traumatopnœa*. *Emphysema* in closed wounds is evidence of wound of the lung, and may be felt as a crepitation along the side of the chest; or it may cause bloating of the entire body. If the wound in the chest wall is large, *hernia* of the lung may result.

Treatment.—Contusions and closed wounds of the lung and pleura usually require no treatment beyond quiet and fixation of the parts. In hemorrhage from open wounds, ascertain the source of the blood. If from the intercostal or mammary arteries, ligate or pack; if from the lung, packing must be depended on, if necessary enlarging the wound by resecting one or more ribs and packing the pleural cavity until the lung is sufficiently compressed to arrest the hemorrhage, as has been successfully done by Da Costa and the writer. Stab- and bullet-wounds of the lungs and pleura should be treated by applying an antiseptic dressing over the wound, without using a probe, fixing the chest with adhesive plaster or plaster of Paris, and keeping the patient quiet, unless there is evidence of dangerous hemorrhage or other indication for immediate operation. *Emphysema* requires no treatment unless excessive, when multiple punctures in the skin and the application of bandages may be necessary.

Hernia of the lung, or *pneumocele*, may occur at the time the wound is received, or later during fits of coughing, or during the process of cicatrization.

Treatment.—Reduce the hernia and close the wound. If this be impossible, try compression or excision.

Pleural Effusions.—Pleural serous effusion, or *hydrothorax*, may affect one or both pleural cavities as a result of acute or chronic inflammation of the pleura, the presence of tumors, foreign bodies, or injuries; or it may be a part of a general dropsical condition (anasarca).

The *symptoms and signs* are: Limited motion of the affected side, bulging and widening of the intercostal spaces, absence of fremitus over the fluid, and dulness or flatness on percussion, which, unless encysted, alters with the position of the patient. The apex of the heart is often displaced and the patient usually lies on the affected

side. Respiratory murmur is weak or absent over the affected side and exaggerated on the sound side.

Hæmothorax is a collection of blood in the pleural cavity, and is usually the result of traumatism or of acute inflammation of the pleura, when the serum may be mixed with blood.

The *diagnosis* is made by the history of the case and an exploratory aspiration.

Empyema simply means a collection of pus, but, unless otherwise indicated, it means pus in the pleural cavity.

Etiology.—Empyema may be the result of traumatism or of a serous effusion which has been infected. It may follow pneumonia, pleurisy, phthisis, influenza, typhoid fever, peritonitis, subphrenic abscess, abscess of the liver, and the following bacteria have been found in the pus: The staphylococcus and streptococcus, the diplococcus of pneumonia, the tubercle bacillus, the typhoid bacillus, and the colon bacillus. In old cases both the visceral and parietal layers of the pleura become enormously thickened and bear little resemblance to their original structure. If unmolested the pus may be absorbed, rupture into a bronchus, burrow between the ribs, to appear behind the mammary gland or on the surface of the chest, or it may pass downward behind the peritoneum and form a pelvic abscess.

Double empyema is rare, but Park has collected ten cases; all operated on with recovery, except one.

The *symptoms* are the same as those given in describing serous effusion (hydrothorax), with the addition of the constitutional symptoms of pus, such as chills, fever, and emaciation. The chest wall is usually œdematous.

Treatment of Pleural Effusions.—Serous effusion and hæmothorax may be absorbed or be followed by empyema. The indications for operation are marked dyspnœa, interference with the heart's action, or a duration of four weeks. Serous effusion and acute empyema may be aspirated, but generally, in empyema, thoracotomy with permanent drainage should be done at once. In old cases, after failure of long-continued drainage, try curettage of the abscess, or Fowler's method of decortication of the lung, or Estlaender's operation, and, as a last resort, Schede's operation.

Operations on the Pleura and Lungs.—*Paracentesis thoracis* is the evacuation of fluid from the chest by a trocar and cannula or by aspiration, the latter method being usually preferred, as the fluid can be withdrawn without the admission of air to the pleural cavity. No anæsthetic is necessary except a little cocaine. Place the patient in a semi-sitting position and insert the needle close to the upper border of the sixth rib in front of the axillary border of

the scapula and draw the fluid slowly to avoid syncope and cough. Faintness, violent cough, or rapid pulse requires arrest of the operation. Withdraw the needle quickly and close the opening with iodoform collodion.

Thoracotomy.—Sometimes the operation may be satisfactorily done under Schleich's solution of cocaine. With the patient in the dorsal position make an incision two or three inches long over the sixth or seventh rib down to the bone, the centre of the incision corresponding to the mid-axillary line. Separate the intercostal muscles close to the upper border of the rib until the pleura is reached. Cautiously open the pleura to avoid wounding the lung. If the space between the ribs is too narrow for the passage of a large rubber drainage-tube, resect one inch of the rib. Insert the finger into the pleural cavity, examine the condition of the pleura, and ascertain the size of the abscess cavity. Do not irrigate at this time, as it may cause alarming shock. After drainage has been established for several days, if necessary irrigation may be cautiously tried, and if well borne salt solution, peroxide of hydrogen, permanganate of potassium 1 to 3000, and bichloride of mercury 1 to 3000, may be used. Expansion of the lung may be promoted by getting the patient to blow into a bottle, or to make expiratory efforts frequently. When the discharge becomes scant, remove the tube.

Estlaender's operation, or *thoracoplasty*, is the operation used in old cases of empyema in which the pleura has become thickened, the lung contracted, so that obliteration is impossible by bringing together the walls of the abscess cavity. As the lung cannot be expanded to reach the chest wall, the latter must be brought down to the lung by resecting a portion of as many ribs as may be necessary. Make an incision in the anterior axillary line, vertical or curved slightly forward, from the anterior axillary fold to the seventh rib. Reflect the soft tissues and expose the ribs from the second to the seventh inclusive. Resect from one to three inches of each rib with bone-cutting forceps, being careful not to injure the intercostal arteries, curette the pleural cavity, insert a large drainage-tube, and close the incision.

Schede's operation is a more radical thoracoplasty, and may be done as a last resort. It consists in removing the outer wall of the abscess cavity, including the chest wall, except the skin. Make a U-shaped flap by an incision beginning at the level of the axilla in front, passing downward to the ninth rib, then upward and backward to a point opposite the second rib. Raise the flap of skin with the scapula from the muscles beneath, and remove the entire chest wall, including the costal pleura and the ribs from the second rib to the bottom of

the pleural cavity, and from the costal cartilages to the tubercles, by means of scissors and bone-forceps. Arrest bleeding, curette the lung pleura, and approximate the skin flap by means of sutures.

Pneumotomy and Pneumectomy.—*Pneumotomy*, simply incising the lung, and *pneumectomy*, excision of a portion of lung, have been performed for abscess, gangrene, bronchiectatic and tuberculous cavities, hernia, and tumors. Seventy-one cases of abscess of the lung treated by pneumotomy and drainage gave forty-nine complete recoveries and sixteen deaths; forty-nine bronchiectatic cavities were operated on with twenty-five recoveries and nineteen deaths; forty-seven cases of tuberculosis of the lung were operated on with twenty-eight recoveries and nineteen deaths; and ninety-six cases of gangrene of the lung operated on gave fifty-three recoveries and thirty-seven deaths (Murphy). Experiments have shown that two-thirds or more of one lung of a dog can be removed without producing death.

Pneumotomy.—Resect a part of two or more ribs and use an exploring needle to locate the abscess. If adhesions exist between the pleural layers, divide the lung tissue at once with a thermocautery, or make a small incision with the knife and dilate with the finger or forceps. If adhesions do not exist, stitch the lung to the chest wall and wait for adhesions before opening the lung. Put in a drainage-tube, but do not irrigate the cavity.

Pneumectomy is performed by exposing the lung, as described, and excising it with the thermocautery or knife, controlling hemorrhage by ligatures and pressure.

CHAPTER VIII.

SURGERY OF THE DIGESTIVE TRACT.

HARELIP AND CLEFT PALATE.—*Harelip* is a congenital defect of the upper lip, rarely of the lower, due to defective development of the branchial arches, and is indicated by a cleft which may involve only the soft parts from a notch in the border to a cleft extending into the nostril; or the cleft may extend through the bones, and if combined with *cleft palate* may extend from the lip in front through the hard

FIG. 227.—Single harelip.

FIG. 228.—Double harelip.

and soft palates behind. Harelip is *simple* when it involves only the lip; *complex* when it includes the alveolar process. *Double harelip* occurs about once in ten cases. *Single* harelip is most frequent on the left side. *Median* harelip is a very rare condition.

In *cleft palate* the fissure may involve only the uvula, the velum palati, or it may extend between the palate processes.

In *single complex* harelip the fissure passes between the intermaxillary and the superior maxillary bones. In *double complex* harelip the fissure extends on each side, and the intermaxillary bone is sometimes attached to the end of the nose as a snout. Occasionally the cleft extends to the orbit on one or both sides external to the wing

of the nose (bucco-orbital fissure). The deformity may interfere with nutrition and later with speech.

Operations should be done between the first and sixth months. Separate the upper lip from the bone on each side of the cleft until the edges can be approximated without tension. Pare both edges of the cleft, beginning at the upper part of the angle and cut-

FIG. 229.—Operation for single harelip.

FIG. 230.—Operation for double harelip: *a*, lines of incision; *b*, parts ready for approximation.

ting downward, but not quite to the border of the lip, leaving a flap attached on each side, so that when approximated a projection is made on the border of the lip to prevent the formation of a notch after healing. Use interrupted silkworm gut or silver wire sutures, passing the first suture through the middle of the lip, approximating the edges

FIG. 231.—Staphylorrhaphy; introducing sutures.

FIG. 232.—Sutures secured, showing gaping of the lateral incisions.

carefully, especially at the border of the lip, using fine catgut or silk if necessary.

In *double harelip* pare both sides of each fissure in the same way, and if the intermaxillary bone project, force it back into position,

breaking it if necessary ; or excise the bone, leaving the skin in place, if healthy. After securing the sutures place a piece of gauze over the wound and hold in place by long strips of adhesive plaster which pass from cheek to cheek across the lip and also serve to prevent tension on the sutures. Remove the sutures between the seventh and tenth days, but retain the plaster until firm union takes place.

Staphylorrhaphy is the operation for closing a cleft in the soft palate. Pare the edges of the cleft in the soft palate and uvula and approximate them with silkworm gut or silver wire sutures inserted by means of a needle with the eye near the point, or from behind forward with a curved needle at each end of the sutures, and secure the ends by tying or with perforated shot. If the tension is great, divide the levator and tensor palati muscles by a longitudinal incision on each side internal to the hamular process.

Uranoplasty is an operation for closing the defect in the hard palate. Pare the margins of the cleft and insert the sutures, but do not tie them. Make an incision through the mucous membrane and periosteum parallel with the cleft and close to the alveolar process on each side ; elevate the flaps of periosteum and mucous membrane from the bone until they can be slid inward and approximated in the median line by tying the sutures. The naked bone is left to heal by granulation.

Brophy operates in the first month, if possible, as follows: First freshen the edges of the cleft, then pass two silver wire sutures from side to side through the maxillary bones in front and behind the malar process and above the palate, securing the ends of the suture on a lead plate on each side. If the edges of the cleft cannot be brought together, insert a knife just below the malar bone and cut the maxilla on each side until it gives way enough to permit approximation.

Salivary Fistula.—This is an abnormal communication between the skin and the duct of one of the salivary glands; usually Stenson's duct is the one affected. The *cause* is a wound or injury or suppuration of the parotid gland during fever.

Treatment.—The object is to make a new mouth to the duct which shall open on the mucous membrane of the cheek. Take a silk ligature with a needle at each end and pass them from the outside of the cheek through the fistula and mucous membrane to the inside of the mouth, a slight distance apart, and tie a tight knot. The thread slowly cuts through the cheek and the duct, causing it to open on the inside of the mouth. Another method is to open the duct in the mouth on the proximal side of the fistula and keep it open by the daily introduction of a probe. The external fistula usually heals spontaneously ; if not, touch it with silver nitrate or the thermocautery.

SALIVARY CALCULUS may form in any of the salivary ducts, but is most common in Wharton's or Stenson's ducts. The *symptoms* are swelling and tenderness of the submaxillary or parotid gland, and the diagnosis is made by examination with the finger and feeling the hard mass in the duct. The *treatment* consists in removing the calculus by squeezing it out or by incision.

INFLAMMATION AND ABSCESSS of the parotid gland are not uncommon in mumps, typhoid fever, gonorrhœa, and other septic diseases. The *symptoms* are swelling of the jaw, just in front of and below the ear, with tenderness and pain on mastication.

Treatment.—Use hot or cold applications and, if suppuration be threatened, early incisions. Avoid the facial nerve by making small incisions parallel with the nerve branches and using the exploring-needle, enlarging the opening, if necessary, by means of hæmostats.

THE TONGUE.

TONGUE-TIE is a congenital abnormal shortness of the frænum, which prevents the protrusion of the tongue to a normal distance beyond the teeth.

The *treatment* consists in dividing the frænum with curved scissors, keeping close to the bone in order to avoid the ranine vessels.

MACROGLOSSIA is an enlargement of the tongue, usually congenital, and is analogous to elephantiasis. The anterior portion of the tongue is usually more affected than the posterior. There is an abnormal development of connective tissue in connection with an increase of lymphatics and blood-vessels (lymphangioma). The condition may be noticed at birth, but sometimes does not develop until several years later. The pressure of the enlarged tongue may distort or dislocate the lower jaw, push out the teeth, and change the shape of the palatine arch. If it is too large to be contained in the mouth, there is constant drivelling of saliva, and the tongue becomes swollen, dry, brown, fissured, and indurated.

Treatment.—This consists in excising enough of the tongue to reduce it to about its normal dimensions. Under anæsthesia, introduce a gag between the jaws, draw the tongue forward with ligatures, excise a V-shaped portion, with the apex behind, large enough to reduce the tongue to its normal size, and bring the edges of the wound together by means of sutures passed through the entire thickness of the tongue.

RANULA is a retention cyst, caused by obstruction to the ducts of the mucous, submaxillary, or sublingual glands of the mouth, and appears as a painless, fluctuating swelling between the floor of the mouth and the tongue. In size it varies from that of a cherry

to an orange, and may be unilateral or bilateral. Ranula may be mistaken for *dermoid cyst*, which sometimes develops in the same locality. The dermoid is not translucent, is more deeply seated than ranula, is usually in the median line, and is often attached to the hyoid bone.

Treatment.—Excise the cyst and *its wall* through the mouth or by an incision beneath the chin, as may seem best adapted to the case.

CARCINOMA OF THE TONGUE. — Cancer of the tongue, which is always epithelioma, is one of the most painful and rapidly fatal

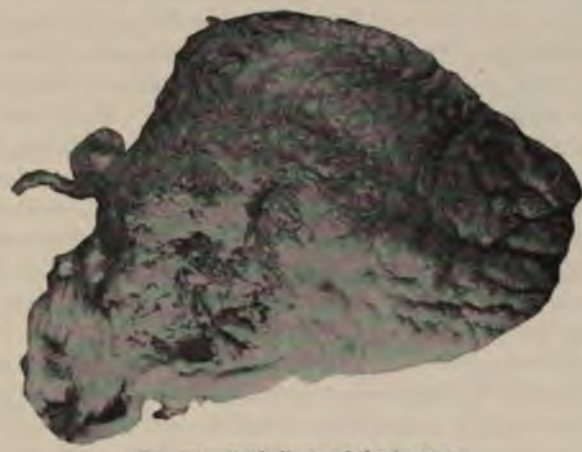

FIG. 233.—Epithelioma of the tongue.

forms of cancer. It occurs between the ages of forty-five and fifty-five years, and more frequently in men than in women,—in the proportion of about five to one. It begins as a small crack, nodule, or ulcer, usually on the border of the anterior portion of the tongue, although it may occur on any part of the organ. The disease is often preceded by leucoplakia or psoriasis of the tongue. Most cases are attributable to some form of chronic irritation, as the habitual use of alcohol, smoking, a rough tooth, a badly fitting tooth-plate, or it may originate in the scars of old wounds or chronic gummatous ulcers, or from the excessive use of caustics in the treatment of benign ulceration of the tongue. The disease spreads rapidly and soon forms a deep ulcer with irregular, indurated edges. The tongue becomes stiff and painful on motion, so that mastication, deglutition, and speech are almost impossible; there is drivelling of saliva, and sometimes severe hemorrhages. The pain is often lancinating in character, and is felt in the tongue and radiates towards the ear. As the disease advances, it may extend from the tongue to

the floor of the mouth, the pillars of the fauces, the soft palate, the tonsils, and even the bone itself; the lymphatic glands in the submaxillary region soon become involved, and finally those of the neck. Death results, in from nine months to two years, from exhaustion, due to constant pain, starvation, and hemorrhage, or from septicæmia.

Diagnosis.—Any chronic ulceration of the tongue in persons past forty or forty-five years of age should excite suspicion. The diagnosis must be made from syphilis and tuberculosis. *Chancre* usually occurs in younger subjects, and is soon followed by enlargement of the lymphatics and the syphilides; *gummata* begin as lumps beneath the surface of the tongue, which ulcerate later; they are found on the dorsum and may be multiple, while the cancerous ulcer is seen on the side of the tongue and is always single. Gummata generally improve or disappear under the use of iodide of potassium, which has no effect on cancer. *Tuberculous ulcers* are more common in young patients, and are almost always preceded or accompanied by tuberculous lesions in other parts of the body. The finding of tubercle bacilli in the discharge from the ulcer would settle the question. In case of doubt, excise the ulcer and examine microscopically, when, if cancer be found, do a radical operation.

Treatment.—Partial or complete excision of the tongue is the only hope, and should be performed at the earliest possible moment. If the growth is small, situated near the tip of the tongue, excise the cancer with a liberal portion of the tongue. If the cancer is situated posteriorly, the tongue should be completely excised, including enlarged lymphatics or other infected tissues, as the tonsil and soft soft palate. When a cure is impossible, palliative operation is often justifiable, as a return of the disease causes less suffering than the primary growth. Excision of a portion of the lingual nerve may relieve pain.

Partial Excision of the Anterior Portion.—Introduce a ligature into each side of the tongue, about half-way back, and draw it forward. Remove a V-shaped portion containing the cancer by cutting between the ligatures, bring the two side-flaps together, and suture them.

Partial Excision of the Side of the Tongue.—If the cancer is situated on the side of the tongue, and it is decided to do a partial excision, introduce two ligatures, one in the tip and the other in the diseased side, behind the point at which the cross-section is to be made. Split the tongue down the middle, free the diseased half from its attachments, and remove a cross-section just in front of the posterior ligature. For the cross-section an écraseur may be used to avoid hemorrhage.

Complete Excision of the Tongue. — Whitehead's Operation.—Draw the tongue well forward by a ligature through its tip, and separate its attachments to the floor, sides of the mouth, and hyoid bone with scissors. Ligate the lingual arteries as soon as cut, and put a strong silk ligature through the glosso-epiglottidean fold, in order to have control of the stump in case of bleeding. *Kocher's Operation.*—Do a preliminary tracheotomy if thought best, and plug the pharynx with sterilized gauze. Ligate the lingual artery on the opposite side and remove enlarged glands. Make an incision from a point just behind the lobe of the ear, along the anterior border of the sternomastoid muscle to its middle, then forward along the hyoid bone, and from this point to the chin; turn up the flap, ligate and divide the lingual and facial arteries and corresponding veins, and remove the lymphatic, submaxillary, and sublingual glands. Divide the mylohyoid muscle and the mucous membrane along the jaw, draw the tongue out through the incision, and remove it close to the epiglottis. Arrest hemorrhage, pack the cavity with iodoform gauze, and close the wound, leaving space for drainage.

FIG. 234. — Incision for Kocher's operation for removal of the tongue.

The after-treatment is important, the dangers being septicæmia, septic pneumonia, and exhaustion. Until able to swallow, from two or three days to a week, feed per rectum or by an œsophageal tube. Change the dressing daily, and irrigate with some antiseptic fluid.

The mortality of excision of the tongue varies from about 5 per cent. in simple cases to 25 per cent. in those cases requiring removal of the tonsil, floor of the mouth, or other parts.

THE ŒSOPHAGUS.

MALFORMATIONS.—Malformations of the œsophagus consist of fistulæ, diverticula, congenital narrowing, closure by a membrane, double tube, or absence of the œsophagus.

Diverticula are sacs communicating with the œsophagus by mouths of various size and situated most frequently opposite the cricoid cartilage.

The *causes* are: Congenital, from defective development of the branchial arches; strictures, causing dilatation of the œsophagus above the point of constriction; *pressure from within* upon a weak area in the œsophageal wall; or *traction from without* as the result of adhesions.

Symptoms.—Unaccountable regurgitation of food. The bougie can sometimes be passed into the stomach without difficulty; at other

times it enters the diverticulum; or two bougies may be used,—while one is in the stomach the other may be passed into the diverticulum. If situated in the neck, a lump may be detected when the sac has been filled with food. Food mixed with subnitrate of bismuth may be given and a skiagram taken.

Treatment.—When accessible the proper treatment is extirpation and suture.

FOREIGN BODIES IN THE ŒSOPHAGUS are most likely to lodge opposite the upper border of the cricoid cartilage, at the crossing of the left bronchus, or at the diaphragmatic opening. Women, children, and lunatics are apt to suffer, and the articles commonly encountered are portions of meat, fish-bones, stones of fruit, whistles, coins, and artificial teeth.

Symptoms.—The symptoms vary, according to the nature of the impacted body, from slight pain and a feeling of irritation to complete obstruction of the œsophagus, interfering with deglutition and respiration, and death may occur from asphyxia. Sharp or rough bodies are apt to produce hemorrhage.

The *diagnosis* is made by looking into the throat with a laryngoscope or œsophagoscope; by external palpation of the neck; by examination with the finger or a bougie, and if necessary by the use of the Roentgen ray. If allowed to remain in the œsophagus the foreign body may ulcerate into the bronchus, aorta, pleura, or pericardium.

Treatment.—When possible, remove the body through the mouth with the finger or forceps. If composed of compressible material it may be pressed out with the fingers or pushed into the stomach with a bougie. Small and medium-sized bodies can often be removed by

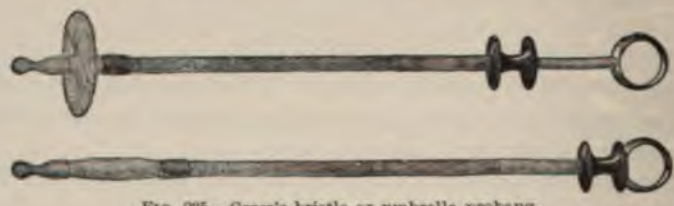

FIG. 235.—Gross's bristle or umbrella probang.

means of a bristle or umbrella probang. If these measures fail, perform œsophagotomy or gastrotomy. In adults the diphragmatic opening is about fourteen and a quarter inches, and the point where the aorta and bronchus cross the œsophagus is about nine inches from the incisor teeth.

STRICTURE OF THE ŒSOPHAGUS may be spasmodic, traumatic, or malignant.

Spasmodic stricture, *œsophagismus*, or *hysterical stricture* occurs most frequently in women who are hysterical, highly neurotic, or the subjects of some reflex irritation, as of the ear, nose, or throat.

Traumatic or *cicatricial stricture* is the result of injury or disease, as the receipt of a wound, swallowing corrosive liquids, or syphilitic ulceration. There is usually no pain, but increasing difficulty in swallowing. The stricture is commonly located opposite the cricoid cartilage, where it may be felt with a bougie.

Malignant stricture is caused by cancer, usually epithelioma, in the lower part of the tube. It may follow simple stricture, and is most frequent in men past forty-five years of age.

The *symptoms* come on gradually, with difficulty in swallowing, especially solid food; vomiting or regurgitation, the vomited matter often containing blood and pus; pain; emaciation; and the passage of a bougie causes hemorrhage. Dilatation of the œsophagus above the stricture may take place, and food, apparently swallowed, may remain here for some hours and then be regurgitated.

Treatment.—For *spasmodic stricture*, pass a bougie, remove any reflex source of irritation, and treat the patient's neurotic condition. *Traumatic* or *cicatricial stricture* requires the systematic use of œsophageal bougies, gradually increasing until the full size is reached. Should this fail, perform œsophagotomy or Abbe's operation. *Malignant stricture* is treated by excision when practicable, or by permanent tubage. Symonds introduces through the stricture a rubber tube from four to six inches long, the upper end of which has a thread attached for removal, and is expanded into a funnel which rests on the stricture. When the tube cannot be used some operation is necessary.

Operations on the Œsophagus. —*Œsophagotomy*—external—may be necessary for the removal of foreign bodies, or for the relief of strictures in the cervical portion of the œsophagus. Make the incision on the left side of the neck opposite the foreign body or the cricoid cartilage, between the trachea internally and the sheath of the great vessels externally. Separate the parts until the œsophagus is reached, open by a longitudinal incision, and remove the foreign body, or treat the stricture. Close the wound in the œsophagus with fine silk sutures to avoid leakage, and the other tissues with silkworm gut sutures, leaving a small opening for drainage in case primary union of the œsophagus should not take place.

Œsophagostomy is indicated in impassable strictures of the upper part of the œsophagus when resection is impracticable. The operation is performed as described above, except that the œsophagus is opened below the obstruction and the edges are stitched to the skin.

Œsophagotomy—internal—corresponds to internal urethrotomy, but is rarely done, on account of the danger, *Abbe's operation* being preferred, as follows: Perform gastrotomy and pass a strong silk string about one yard long from the stomach through the œsophagus and mouth, so that one end of the string projects out of the mouth and the other end out through the opening in the stomach. The stricture is cut through by using the string as a saw. The after-treatment consists in the systematic passage of bougies.

Œsophagectomy—resection of the œsophagus for stricture, with union of the two ends—has been successfully performed, according to Escher, one and one-half centimetres of the tube having been extirpated.

Surgery of the Abdomen.

WOUNDS of the abdomen are divided into penetrating and non-penetrating. *Non-penetrating*, as a rule, are not as serious as penetrating wounds, although it must not be forgotten that rupture of the viscera, stomach, intestines, liver, spleen, kidneys, and bladder have not infrequently been produced by injuries to the abdomen which have not even broken the skin. A *contusion* of the abdomen which does not rupture the viscera sometimes produces serious symptoms from shock, probably due to the effect on the solar plexus or other parts of the sympathetic nerve. *Ventral hernia* may follow, or abscess and fatal peritonitis.

Penetrating Wounds.—Penetrating wounds are those in which the peritoneal cavity has been opened and, other things being equal, are much more serious than non-penetrating wounds on account of the danger of peritonitis. The most frequent *causes* of penetrating wounds of the abdomen are stabs and gunshot wounds.

Symptoms.—The symptoms of *non-penetrating* wounds depend on the nature of the wound and whether or not the viscera are injured. *Penetrating* wounds when large can easily be recognized, but when produced by small pointed instruments or by bullets it is sometimes difficult. The symptoms depend on whether or not an important organ has been wounded. If so, shock is shown by a rapid feeble pulse, which may be slow at first, cold sweating, shallow respiration, and often vomiting. Severe hemorrhage is indicated by restlessness and thirst. Pain varies in degree, and is sometimes absent. Symptoms of injuries to *special organs* are as follows: Vomiting of blood or the passage of blood by the bowels would point to a wound of the stomach or bowels; blood in the urine, injury to a kidney or the bladder. Laceration of the liver or spleen would be indicated by symptoms of internal hemorrhage. Peritonitis may appear within a few hours, and may be indicated by distention of the bowels with gas

or the presence of free gas in the peritoneal cavity, as denoted by the disappearance of the liver dulness.

Diagnosis.—It is important to ascertain if the cavity has been penetrated and whether or not the viscera have been wounded. The viscera are more likely to escape injury in stab than in gunshot wounds. A bullet passing through the abdominal cavity from side to side is more likely to wound the viscera than one which passes through anteroposteriorly. The escape of stomach or intestinal contents or of urine through the wound would be proof positive of visceral injury. Often it is impossible to follow the course of the bullet by means of a probe. In doubtful cases, especially of gunshot wounds, prepare the patient for laparotomy; give an anæsthetic, and follow the wound, dividing the tissues layer by layer until it is determined whether or not the peritoneal cavity has been entered. If the peritoneal cavity is opened, enlarge the wound sufficiently to examine the viscera.

The *prognosis* in *non-penetrating* wounds without injury to the viscera and in *penetrating* wounds without infection or injury of viscera is good. Wounds of the stomach, intestines, liver, spleen, and large blood-vessels are grave injuries, yet the mortality from stab and gunshot wounds of the abdomen *with injury to the viscera* when treated by timely operation should not exceed 30 or 40 per cent.

Treatment.—*Non-penetrating* wounds are treated on general principles. In *small stab wounds* in which the viscera have probably not been injured it may be justifiable to close the wound, dress it aseptically, keep the patient quiet, and await results. In *gunshot wounds* penetrating the abdominal cavity, operate, provided the facilities for operation are at hand. If the ball has passed through the body laterally or diagonally, make an incision in the median line; but if it has passed through the body anteroposteriorly, make the incision through the wound of entrance or exit. Sometimes it is necessary to supplement the longitudinal incision by a cross incision through the rectus. If there is serious hemorrhage, arrest it without delay by ligation of the bleeding point or by packing. A lacerated spleen or kidney may require removal. Laceration of the liver should be closed with catgut sutures or packed with gauze. To obtain a clear field in order to find the source of hemorrhage, the aorta may be temporarily compressed between the fingers just below the diaphragm. Search for perforations by drawing out the first coil of intestine which presents; examine the entire small intestine by drawing out the coils at one end of the wound while an assistant pushes them in at the other. Close each wound as soon as found, using a round needle with a continuous suture of fine silk, six stitches to the inch, through the peri-

toneal and subserous coats, approximating the serous coats and turning a liberal portion of the edges in to allow for sloughing. It is not necessary to trim the edges of the wound, as troublesome hemorrhage might be started. With organs which cannot be drawn into view a wound can often be detected by careful palpation. If there has been little hemorrhage, no escape of intestinal or stomach contents, and probably no infection, irrigation is unnecessary; otherwise irrigate freely with warm salt solution. The same conditions determine the question whether or not drainage is necessary. For drainage, glass tubes or strips of iodoform gauze may be used. Close the external wound by passing interrupted silkworm-gut sutures through *all* the tissues, and before tying them unite the peritoneum and layers of fascia by continuous catgut sutures.

PERITONITIS.—Peritonitis, or inflammation of the peritoneum, may be *acute* or *chronic*, *local* or *general*.

Etiology and Pathology.—The *predisposing causes* are conditions which injure or lower the vitality of the peritoneum, as wounds, cold, and interference with the circulation. The *exciting causes* are pathogenic bacteria, especially the staphylococcus, streptococcus, pneumococcus, colon bacillus, gonococcus, and tubercle bacillus. These organisms reach the peritoneum in various ways: from *without* by the introduction of unsterilized hands, instruments, or other objects; from *within*, by extravasation of stomach or intestinal contents; from the rupture of a diseased appendix, gall-bladder, kidney, Fallopian tube; from strangulation due to hernia, volvulus, intussusception, thrombosis or embolism of a mesenteric vessel, the twisting of a pedicle of an ovarian tumor, or floating kidney or spleen; and sometimes the infectious organism is brought by the *circulation* to tissues rendered especially favorable to its growth as a result of injury or disease. Chemical substances and mechanical injuries excite a *plastic* or *reparative peritonitis*, which has no relation to bacteria and is probably unattended by the formation of toxic ptomaines. Such a form of peritonitis follows aseptic operations on the peritoneum. In peritonitis the usual phenomena of inflammation take place, with dilatation of the blood-vessels, stagnation of the blood current, escape of leucocytes, and proliferation of fixed connective-tissue cells. Thus, lymph is formed which glues together the peritoneal surfaces and has a tendency to limit the spread of the process. If the inflammation is more severe on account of larger numbers or greater virulence of the bacteria, many of the cells die and pus is formed—*suppurative peritonitis*. If the phagocytes and leucocytes are able to overcome the invading bacteria, the suppurating area is shut in by adhesions—*circumscribed* or *local peritonitis*.

Otherwise the inflammation and suppuration spread, until the greater portion of the peritoneum is involved, and *general suppurative peritonitis* is the result. Sometimes the virulence of the toxin produced by the infectious agent is so great that life is destroyed before the inflammatory process has reached the stage of suppuration, death being due to toxæmia—*septic peritonitis*. This form is seen after perforation of the alimentary tract in gastric or intestinal ulcer, appendicitis, or abscess. According to George Ryerson Fowler, absorption is most active in the region of the diaphragm, so that peritonitis here is most likely to be fatal, while it is least likely to be so in the pelvic region, where absorption takes place much more slowly.

Symptoms.—The symptoms of *local suppurative peritonitis* are chill or chilly sensations (not always present), general and local pain, tenderness, rigidity of the muscles over the affected part, distention of the abdomen, constipation, vomiting, and elevation of temperature, which may become normal after the abscess has been walled in; the pulse is accelerated—100 to 120; the patient usually lies on the back with the thighs flexed; in a few days a hard mass, due to the formation of an abscess, can be felt in the affected region. The symptoms of *general suppurative peritonitis* are similar to those described as occurring in the circumscribed form, except that they are more severe. There is more apt to be a chill, followed by a fever (102° to 104° F.), though sometimes the temperature is normal or subnormal. There are usually severe pain, obstinate vomiting, constipation, with great distention of the abdomen (in some cases there is no distention, and the abdomen may be flat and not rigid), and the pulse is rapid and weak—from 120 to 150. The symptoms in the *septic* form of peritonitis are as follows: There is sometimes a chill, followed by elevated temperature and rapid, weak pulse,—140 to 160 to the minute,—with obstinate vomiting, severe pain, and great abdominal distention. Not infrequently the temperature is subnormal during the entire course of the disease, and there may be no pain or abdominal distention.

Prognosis.—In *local peritonitis* the prognosis is favorable. In the *general suppurative* and *septic* forms, if the entire peritoneum is involved, death is almost inevitable. However, many cases of so-called *general peritonitis* are, strictly speaking, local.

Treatment.—In peritonitis following operations, give sulphate of magnesia on the appearance of the first symptoms, until purging takes place. In *circumscribed* peritonitis or in the earliest stages of *general* and *septic* peritonitis, operation is indicated. After the establishment of *general* peritonitis, septic or suppurative, operation is usually done, but is often useless. Perhaps the best treatment is

that recommended by Ochsner in appendicitis,—the prohibition of all food by the mouth and the administration of opium to quiet the peristalsis, and rectal feeding, in the hope that the inflammation will subside and the patient may rally.

TUBERCULOUS PERITONITIS is a local form of tuberculosis which manifests itself as a chronic peritonitis with effusion—*tuberculous ascites*. The disease is usually primary, but may be secondary to lesion of the abdominal organs, or it may be a result of phthisis or a part of an acute miliary tuberculosis. The peritoneum is covered with tubercles, in some cases large tuberculous masses being formed. Adhesions take place, the masses may break down and form abscesses, but there is a large effusion of serum in the peritoneal cavity.

Symptoms.—The disease occurs most frequently in young women, though it may occur at any age and in either sex, beginning with fever, which may be noticed only in the evening. Disordered digestion, emaciation, pain and swelling in the abdomen follow, palpation reveals the presence of fluid in the abdominal cavity, and masses of adhesions may be felt. Intestinal obstruction may occur.

Treatment.—Some of the cases recover spontaneously, others die from tuberculosis of other organs. More than half of the cases operated on have recovered. The operation consists in doing a laparotomy, carefully breaking up adhesions, evacuating the fluid, and establishing drainage.

SURGERY OF THE LIVER.

HEPATOPTOSIS, *movable or floating liver*, is a rare condition, due to relaxation of the ligaments and abdominal walls which usually furnish support. It may be a part of a generally relaxed condition accompanying gastroptosis and enteroptosis, and is sometimes congenital. It is more common in women than in men, in the proportion of four to one.

Treatment.—An elastic support may be worn to keep the liver in place, and if this fails *hepatopexy* may be performed, and the liver sutured to the abdominal walls or margin of the diaphragm, or the round ligament may be shortened.

HYDATIDS OF THE LIVER are caused by the embryo of the dog tapeworm,—the tænia echinococcus,—the ova of which are taken into the human alimentary canal, where they hatch, enter the portal circulation, and are carried to the liver. Here the embryo, which has a small head and mouth armed with a crown of hooklets resembling a cat's claws, attaches itself by its head and hooklets, "scolices," while its body develops into a cyst containing fluid and numerous daughter cysts.

Symptoms.—Steady, painless enlargement of the liver until a fluctuating tumor is formed in which the hydatid *fremitus* may be obtained. Pressure on the vena cava may cause œdema of the lower extremities. If infection takes place with suppuration, symptoms of abscess of the liver develop. The cyst may burst into the lung, and the hooklets may be recognized in the sputum, or it may burst into the peritoneal cavity and cause death from peritonitis. The *diagnosis* can be made positively only by finding the hooklets, which resemble small cat's claws.

Treatment.—Expose the tumor by an incision over its most prominent part, insert an aspirating needle, draw off the fluid, seize the sac by means of forceps, and as it becomes empty draw it through the opening. Stitch the edges of the opening in the liver to the abdominal wall, and put in a drainage-tube or iodoform gauze.

ABSCESS OF THE LIVER may be *solitary* or *multiple*. The *exciting causes* are pyogenic organisms, as the amœba, the bacillus coli communis, etc. *Predisposing causes* are dysentery, diarrhœa, appendicitis, enteric fever, malaria, disease of the gall-bladder and ducts, inflammation affecting the portal system, excessive use of alcohol, or cold. The *solitary* or *tropical abscess* is usually of large size and situated in the right lobe. The *multiple* abscess is usually pyæmic, as a result of suppurating foci in the region drained by the portal vein.

Symptoms. — Increased liver dulness, sometimes bulging in the right hypochondrium; pain and tenderness on pressure, especially if the abscess is near the surface of the organ; and pain is often felt in the right shoulder. The patient does not feel well; his appetite is capricious; he loses flesh; his tongue is furred and complexion sallow; he may have slight chilly sensations with evening rise of temperature, or severe rigors with high fever, profuse sweats, and rapid pulse. Jaundice rarely occurs. Abscess near the upper surface of the liver is apt to cause cough and dyspnœa; in the centre, jaundice; and near the inferior surface, nausea and vomiting. The symptoms are often obscure.

The *diagnosis* may be made by aspiration, inserting a good-sized needle in the most prominent part of the swelling, or in the axillary line between the seventh and eighth ribs. If pus is found, proceed with the operation at once to avoid peritonitis from leakage, though the pus of such abscesses is frequently sterile.

The *prognosis* of abscess of the liver is always serious, *septic* or *pyæmic* cases being almost invariably fatal. Early recognition and prompt operation on the *solitary* abscess should not give a mortality exceeding 25 per cent. If let alone the abscess may break into adja-

cent organs, the most common being the pleural cavity or base of the right lung, the stomach, bowel, or pericardium.

Treatment.—The indications are to evacuate the pus and establish drainage. Open the abdomen over the most prominent part, and if adhesions exist between the liver and abdominal wall, open the abscess from the outside through the site of the adhesions and close the laparotomy wound. If no adhesions exist, stitch the surface of the liver around an area at least one inch in diameter to the abdominal wall, pack around with gauze, evacuate the pus with a trocar and cannula, enlarge the opening in the liver by incision, stitch the edges to the skin if possible, and put in a drainage-tube or gauze packing. Irrigation is seldom necessary except in septic cases.

CIRRHOSIS OF THE LIVER WITH ASCITES.—*Talma's Operation.*—In order to establish collateral circulation Talma of Utrecht first suggested and Van der Meule performed the first operation in 1889, which was fatal. Subsequently, but independently, it seems, the operation was successfully performed by Drummond and Morison, of England, in 1894 and 1895. The operation is performed as follows: Open the abdomen, evacuate the fluid, and stitch the great omentum to the abdominal parietes with catgut over a space of four or five inches, first rubbing with gauze or scarifying the peritoneum of the abdominal wall. This permits of the establishment of circulation between the vessels of the great omentum and those of the abdominal wall. Packard and Leconte[1] give twenty-two cases of this operation with five immediate deaths, two later deaths, three unimproved, three improved, and nine recoveries,—an excellent showing in the treatment of a disease which is usually considered incurable. Brewer[2] reports the results of sixty cases operated on, as follows: Twenty-two immediate deaths and six cures lasting two years and longer.

THE GALL-BLADDER AND BILE DUCTS.

As a result of injuries the gall-bladder or bile ducts may be ruptured and bile escape into the peritoneal cavity, giving rise to shock, pain, vomiting, and the symptoms of peritonitis if the bile be infectious.

The treatment consists in opening the abdomen, and, if possible, repairing the injury. Cholecystectomy may be necessary. If the ducts are injured, drainage should be provided.

GALL-STONES (CHOLELITHIASIS).—Gall-stones are concretions composed of cholesterin and bile salts, sometimes mixed with blood-

[1] American Journal of the Medical Sciences, March, 1901.

[2] Medical News, February 8, 1902.

clot, epithelium, and bacteria, which form in the gall-bladder or bile ducts. In color they vary from pale yellow to green or dark brown.

Causes.—*Cholelithiasis* is the physical condition which leads to the formation of gall-stones. It occurs most frequently in middle and advanced life, and in women in the proportion of four to one. In Germany 10 per cent. of the people have gall-stones, but only 5 per cent. of these suffer from them (Kehr). In America about 7 per cent. have gall-stones (C. D. Mosher). A lack of balance between ingestion and assimilation, high living, too little exercise, a catarrhal or inflammatory condition of the bile ducts from invasion by pyogenic organisms, such as the colon or typhoid bacilli, pneumococci, etc., are important etiological factors.

Symptoms.—Symptoms of gall-stones vary according to the location of the stone, the amount of obstruction produced, and whether or not there is infection.

Biliary colic is caused by the passage of a stone through the ducts or by inflammatory obstruction of the ducts. It often begins suddenly two or three hours after a meal, with severe spasmodic pain in the hepatic and epigastric region, nausea, vomiting, distention of the abdomen, and often chills and profuse perspiration. The attack lasts a few minutes or several hours, and is terminated by the stone passing into the intestine, falling back into the gall-bladder, or becoming impacted in the duct, when the symptoms assume a subacute character. Examination of the fæces after an attack may show the presence of a stone. If the stone lodge in the *common* duct, the patient becomes jaundiced, and remains so while the impaction lasts. If it lodge in the cystic duct, it does not cause jaundice, but the gall-bladder becomes filled with mucus, producing hydrops, or, if it become infected, empyema of the gall-bladder, or suppurative cholecystitis. A stone in the common duct may not be impacted, but may act as a ball valve, moving up and down and producing intermittent colic and jaundice. If the gall-stone remain impacted in the common duct, it may increase in size and gradually perforate the walls of the duct and of the intestine until it enters the lumen of the latter. Gall-stones as large as a hen's egg have been known to enter the intestine, and have produced obstruction of the bowel by lodging in the small intestine.

Suppurative cholecystitis may be *acute* or *chronic*, and occurs not infrequently during or following typhoid fever, puerperal fever, or other forms of sepsis, often with gall-stones as a predisposing cause. The inflammatory process may be *acute* and result in perforation or gangrene of the gall-bladder and general peritonitis, or it may be *chronic* and result in empyema of the gall-bladder, or the pus may enter the liver, stomach, intestines, pleura, or point externally.

Symptoms.—The symptoms in the *acute* form are sudden severe pain on the right side of the abdomen, persistent vomiting, tympanites, rapid pulse, hurried respiration, and an anxious expression of countenance, sometimes chills, fever, and profuse perspiration. In the *chronic* form the pain is not so severe, the fever and chills may be intermittent, the disease runs a milder course, and a tumor may be felt in the region of the gall-bladder.

The *diagnosis* must be made from appendicitis or peritonitis. From *appendicitis* it may be distinguished by the location of the pain at a higher point, in the region of the gall-bladder, thorax, and epigastrium. In any of these conditions a prompt laparotomy is indicated.

Cholangeitis is inflammation of the bile ducts, including the common, the cystic, and the biliary ducts.

The *predisposing* causes are gall-stones, hydatid disease, cancer of the bile ducts, influenza, and typhoid fever. The *exciting* causes are pathogenic bacteria.

Symptoms.—The symptoms may be mild or severe. The patient, who often gives a history of previous attacks of biliary colic, is taken with a chill or a rigor, with fever—104° to 105° F.—and rapid pulse. Pain may be absent, but is usually present, with tenderness and swelling of the liver. Jaundice is intense and persistent, the fever continuous with occasional chills and profuse perspiration, the patient loses strength rapidly and may die of pneumonia, pleurisy, endocarditis, abscess of the liver or gall-bladder, or general septicæmia.

Tumors of the gall-bladder and ducts may be benign or malignant, and may produce obstruction when located in the ducts, with symptoms resembling gall-stones. Cancer may be recognized by a rapidly developing tumor, persistent jaundice, and progressive loss of flesh and strength, but it is often associated with gall-stones, so that a differential diagnosis is impossible before operation.

The *treatment of gall-stones* and the different forms of inflammation which attend them is chiefly surgical. Unless the symptoms be urgent, or recur frequently, medical treatment, the alkaline mineral waters, large quantities of olive oil, or phosphate of sodium in drachm doses once daily, may first be tried. The pain of biliary colic must be relieved as far as possible by the hypodermatic use of morphine, the warm bath, or inhalation of chloroform. The patient's diet, exercise, and habits should be regulated. If this treatment fail no time should be lost in resorting to surgery.

OPERATIONS ON THE GALL-BLADDER AND BILE DUCTS.—Operation in cases of long-standing jaundice is often attended by troublesome or even fatal hemorrhage, which seems to be due to the want of

coagulability in the blood. To avert danger on this account, the coagulability should be tested in every doubtful case before operating. If the time of coagulation exceed five minutes, operation is contraindicated, unless imperative. Mayo-Robson uses chloride of calcium, as recommended by Wright, in thirty-grain doses every four hours for a few days before and for some time after the operation, in order to increase the plasticity of the blood.

Cholecystostomy is indicated in nearly all operative procedures on the gall-bladder and bile ducts in addition to whatever other operation may be necessary. Make Kocher's oblique incision parallel to the margin of the costal cartilages, or a vertical incision from the tip of the ninth costal cartilage. Expose the gall-bladder, which is often shrunken and adherent, hold the wound open by long retractors, and isolate the gall-bladder by packing with gauze. If distended aspirate it, catching any leakage on small bits of cotton, which are instantly removed, open the bladder, remove the stones with a scoop or forceps, and examine the cystic and common ducts as far as the duodenum for other stones. If found, work them back into the gall-bladder, or break them with a needle or by pressure with the fingers (cholelithotrity); or choledochotomy may be necessary. Pass a flexible probe through the ducts to the bowel, to see if they are clear. Then suture the outer surface of the gall-bladder for a third or a quarter of an inch from the margin of the opening, to the parietal peritoneum and fascia; the *edges* of the opening are sutured to the skin or to the muscle just under the skin, first placing a collar of iodoform gauze between the two rows of sutures around the opening in the gall-bladder. When drainage is no longer required, the *external* row of sutures is removed and the mouth of the gall-bladder detached from its adhesions to the skin or muscle, not disturbing the

FIG. 236.—Biliary vessels, gall-bladder, etc.: *a*, gall-bladder; *b*, cystic duct; *c*, hepatic duct; *d*, duct from right lobe of liver; *e*, common bile duct; *f*, opening of common duct in duodenum; *g*, duct of Wirsung; *h*, pancreas. (After Gray.)

internal row of sutures, the collar of gauze is removed, and the opening retracts and readily closes. When it is impossible to bring the gall-bladder to the abdominal wall, a rubber tube may be inserted and the gall-bladder carefully stitched to the tube by means of catgut sutures. The bile drains out through the tube three or four days, then ceases if the bile ducts are patulous, and the drainage-tube can be removed. In cholangeitis or severe cholecystitis the drain should be kept in from one to two weeks.

The mortality of uncomplicated cholecystostomy is only 1 per cent., but in complicated cases over 50 per cent. (Kehr).

In *cholecystotomy* the gall-bladder is closed at once after removing a stone. When the sutured gall-bladder is attached to the abdominal incision, which is also closed over it, the operation is called *cholecystendysis*. These operations are suitable only when there is no disease of the gall-bladder.

Cholecystectomy means excision of the gall-bladder, and is indicated in inflammation, in cancer, in wounds of the gall-bladder, and in stricture of the cystic duct. Obstruction of the common duct is a contraindication to cholecystectomy. The operation is performed by exposing the gall-bladder, as above described, incising the peritoneum which attaches it to the liver at its base and sides, until the cystic duct is reached. The duct is ligated and divided and the end sterilized by touching it with the actual cautery or with a strong solution of bichloride. The abdominal wound is then closed without drainage.

The mortality is 5 per cent. (Kehr). Others give a mortality of from 15 to 25 per cent.

The gall-bladder may be obliterated by opening it, dissecting out the entire mucous membrane, and closing the incision.

Choledochotomy is indicated in impacted gall-stone when cholelithotrity has failed, and in cholangeitis for drainage. Open the abdomen as described, separate the adhesions, and hold the liver up and the edges of the wound open by means of retractors. Insert the left forefinger into the foramen of Winslow, from right to left, behind the hepatic vessels and the common duct, catching them between the finger and thumb. Locate the stone and remove it through an opening made near the mouth of the duct, in order to avoid the portal vein. Where the stone has lodged at the mouth of the common duct, it may be removed by incising the duodenum (choledochoduodenotomy) and stretching or incising the mouth of the duct. The opening in the duct may be closed by means of sutures; but if there has been cholangeitis, it should be left open. In any case drainage should be provided, and if the duct is left open the drainage-tube

may be sewed into the duct with catgut and then packed around with iodoform gauze.

Cholecystenterostomy and *choledochenterostomy* are operations for making a communication between the gall-bladder or the dilated common duct and intestine—the duodenum, jejunum, or colon. It is indicated in permanent occlusion of the common duct from any cause. The operations may be done by simple suture or by the use of the small Murphy button.

THE PANCREAS.

The pancreas is situated in such an inaccessible position that operations upon it are performed only with great difficulty. Experiments have shown that animals live after complete extirpation of this organ. F. Franke removed the entire pancreas from a man for malignant disease, and the patient lived five and a half months without diabetes, dying from recurrence of the disease.

PANCREATITIS may be *acute* or *chronic*, and is caused by infection from the intestine or common bile duct. A small stone obstructing the papilla may cause backing up of infected bile into the pancreatic duct. The inflammatory process may be acute and attended by hemorrhage or gangrene; or the process may be slower, resulting in abscess or an increase in the connective tissue of the organ, producing a hard, tumor-like mass.

Symptoms. — *Acute pancreatitis* with gangrene begins suddenly, with severe pain in the epigastric region, tenderness, nausea, and vomiting, followed by symptoms of collapse or of peritonitis or septicæmia. *Pancreatitis* with the formation of *abscess* is not so rapid in its course; the symptoms may extend over a period of several months. It usually occurs in middle-aged persons. The symptoms begin suddenly, possibly after an attack of jaundice, with nausea, vomiting, severe pain, and distention of the abdomen. In the course of a few days the symptoms become less severe, but fever develops, which may be attended with chills and symptoms of septicæmia; there is increased leucocytosis, and a tumor may be detected just above the umbilicus. The stools may contain fat.

Treatment. — In *gangrenous pancreatitis* operate promptly and remove the gangrenous portion,—a feasible operation, except when the head of the organ is involved. In *abscess* open the abdomen over the tumor, if one exist, otherwise through the left rectus muscle, evacuate the pus, unite the edges of the abscess walls to the external wound, and drain.

CYSTS OF THE PANCREAS, according to Senn, are always of the retention variety, and are caused by obstruction of the common duct or some of its branches.

The *symptoms* are discomfort, vomiting, constipation, or diarrhœa, perhaps sugar in the urine, fat in the fæces, loss of flesh, and often a bronzed or muddy hue of the skin. Examination reveals a tumor, usually in the median line just above the umbilicus or towards the left, as cysts develop more frequently in the tail of the pancreas. A resonant area may be found above or just over the tumor (stomach or transverse colon). The cyst may grow slowly or rapidly and attain the size of a man's head.

Treatment.—Perform cœliotomy over the tumor or through the left rectus muscle, turn aside or divide the omentum or mesocolon when necessary, empty the cyst with an aspirator or trocar and cannula, and remove the cyst wall. If the cyst is connected to the pancreas by a pedicle, it may be ligated, cut away, and the abdominal wound closed. If the cyst wall cannot be safely removed, suture it to the abdominal wound and drain until recovery takes place.

THE SPLEEN.

INJURIES OF THE SPLEEN.—The spleen is sometimes penetrated or perforated by stab or gunshot wounds or fractured ribs, or it may be ruptured as a result of blows, falls, or crushing force.

The *symptoms* are chiefly those of internal hemorrhage with pain in the splenic region.

Treatment.—Unless life be threatened by hemorrhage or infection, injuries of the spleen should be treated by strict antisepsis and rest. In severe hemorrhage threatening life open the abdomen, suture or pack the wound, or, if that be impracticable, excise the spleen.

In thirty-five cases of splenectomy for rupture there were fourteen deaths.

WANDERING SPLEEN may be caused by the increased weight of the organ, stretching or rupturing its ligaments.

The *treatment* consists in the use of bandages to hold the spleen in place, splenopexy or splenectomy,—the last giving the most satisfactory results.

ABSCESS OF THE SPLEEN is generally due to septic embolism or infarcts from some infectious process, as appendicitis, going on in the abdomen. It sometimes follows contusions. The abscess may be single or multiple; in the spleen or external to the spleen,—perisplenic abscess.

The *symptoms* are: Pain in the splenic region, tenderness on pressure, increase of splenic dulness, and perhaps hectic fever. The abscess may burst into the stomach or bowels.

Treatment.—If fluctuation be detected and adhesions have formed, the abscess may be opened and drained. In perisplenic abscess extir-

pate the spleen. Of seven cases of abscess treated in this manner all recovered (Hagen).

SPLENECTOMY.—Make an incision through the left rectus muscle, supplemented if necessary by a transverse incision. If adhesions exist divide them between double ligatures. Divide the suspensory ligament, introduce the hand between the spleen and diaphragm, and pull the spleen down and turn it over, bringing the vessels of the hilus into a convenient position for ligation. Tie the vessels separately before removing the spleen, or clamp the pedicle, cut off and remove the spleen, and then tie the vessels separately.

Splenectomy has been done for malarial spleen, splenic anæmia, chronic splenic enlargement of infancy, and Banti's disease (hypertrophy with cirrhosis of the liver). Péan in 1867 performed the first successful splenectomy.

The *mortality* of three hundred and sixty splenectomies was 38.3 per cent. (Hagen). When performed for splenic leukæmia the mortality is very high, forty-three operations resulting in only five recoveries (Warren). Splenectomy is nearly always followed by an increase in the total number of white blood-corpuscles and a decrease in the number of red cells and hæmoglobin; but these changes are only temporary, the patient being finally fully restored to health.

THE STOMACH.

CONGENITAL MALFORMATIONS, as hour-glass contraction, contraction of the pylorus, or complete atresia, are occasionally seen.

INJURIES OF THE STOMACH. (See WOUNDS OF THE ABDOMEN.)

FOREIGN BODIES—pins, needles, buttons, whistles, coins, false teeth, knives, forks, spoons, and hair—may be taken into the stomach accidentally or on purpose by children, jugglers, or insane persons.

Treatment.—When small bodies have been swallowed, such as pins, buttons, etc., give a diet composed principally of bread and milk and potatoes, in order to form a coating for the foreign body and thus protect the mucous membrane of the intestine. Do not give purgatives. Bodies which cannot pass the pylorus, or which would endanger the intestines if they did pass, or small bodies which remain an unreasonable time in the stomach, as shown by the Roentgen ray, must be removed by gastrotomy.

ULCER.—According to Brinton and Welch, gastric ulcer is found in 5 per cent. of all necropsies, and, while it may occur at any part of the stomach, it is found most frequently at the lesser curvature on the posterior wall, near the pylorus.

The *causes* are: Injury, alcoholism, anæmia, hyperacidity of the gastric juice, and embolism of a terminal artery—sometimes seen in burns of the skin.

The *acute* or peptic ulcer (probably caused by the action of the gastric juice) is small, round, punched out, single or multiple, and is found chiefly in young women, often single women, with amenorrhœa and chlorosis. This ulcer is not infrequently located near the cardiac end of the stomach. The *chronic* ulcer occurs more frequently in men, in the proportion of about three to one. It is usually single, with irregular, sloping, thickened, indurated edges, and is often attended with adhesions. It occurs in middle or advanced life, sometimes in youth, and is located most frequently at or near the pylorus.

Symptoms.—The general symptoms are pain or uneasiness after eating, vomiting, and tenderness over the stomach. Blood is vomited from repeated small hemorrhages, or one hemorrhage may be so severe as to cause rapid death. In some cases the first symptom is the occurrence of hemorrhage or the symptoms of perforation—sudden pain in the epigastric region, followed by vomiting, shock, collapse, and peritonitis.

The *diagnosis* from cancer is often difficult, especially the chronic form of ulcer, which is often accompanied with a tumor at the pylorus and dilatation of the stomach. In ulcer there is often an excess of hydrochloric acid, while in cancer it is diminished or absent. In ulcer the blood vomited is usually bright red; in cancer it is dark colored—coffee-grounds in appearance. In ulcer there are anæmia and loss of flesh, while in cancer there is a cachectic appearance, with rapid emaciation. Cancer may develop on the site of an ulcer.

Complications. — Either form of ulcer may be complicated by severe hemorrhage or sudden perforation; but the acute form more frequently. In either form perforation may occur slowly after the formation of adhesions and a subphrenic abscess result. (This is more likely to occur in the *chronic* form.) In *chronic* ulcer the complications may be cicatricial contraction of the pylorus, with dilatation of the stomach, hour-glass contraction, adhesions, tumor of the pylorus, tetany, hepatitis, pancreatitis, stricture of the bile ducts, jaundice, uncontrollable vomiting, and profound anæmia (Mayo-Robson). Perforation occurs in about 7 per cent. of the cases of gastric ulcer, and by means of operation about 25 per cent. of the cases are saved (McCosh).

Treatment.—The *medical treatment* consists in keeping the patient in bed and using rectal alimentation, giving by the mouth nothing

but water and subnitrate of bismuth in drachm doses three times a day, until the pain is relieved. *Surgical treatment* is required for perforation, hemorrhage, contraction of the pylorus, or hour-glass contraction. In *perforation* the prompt performance of laparotomy is imperative. Search for the perforation by careful examination of the stomach and, when found, close it by inverting the edges and introducing one row of sutures through the peritoneal and muscular coats; or, if the patient's condition permit, excise the ulcer and approximate the edges by two rows of sutures, one through all the coats and the second through the peritoneal and muscular coats, inverting the first. If the stomach contents have escaped, sponge out and irrigate the peritoneal cavity with salt solution, and close the wound without drainage. If possible, perform the operation before perforation occurs.

HEMORRHAGE, if chronic and persistent, should be treated by laparotomy. Open the stomach, find the ulcer, and excise it if possible. If in the pylorus, pyloroplasty or gastro-enterostomy may be necessary after excision. *Acute hemorrhage* is often a contraindication to immediate operation, the patient's condition being so bad that the additional shock of operation would be almost certainly fatal. In such cases medical treatment is indicated until the patient has rallied, when the question of operation may be considered.

PYLORIC CONTRACTION (STRICTURE) AND HOUR-GLASS CONTRACTION result from ulceration, or they may be congenital. Stricture of the pylorus may be treated by pyloroplasty, excising the ulcer, should one be present; by gastroduodenostomy; or pylorectomy. *Hour-glass contraction* is to be treated by gastroplasty or gastrogastrostomy.

CANCER OF THE STOMACH.—Benign tumors of the stomach are rare. Myoma, lipoma, papilloma, adenoma, lymphadenoma occur occasionally, and sarcoma sometimes as a secondary growth. By far the most common tumor of the stomach is carcinoma—usually scirrhus. According to Richardson, between .5 and 2.5 per cent. of the mortality from all causes is due to cancer of the stomach, and between 35 and 40 per cent. of all cases of cancer originate in the stomach. The most frequent site is the pylorus, next the cardiac orifice of the stomach.

Symptoms.—Cancer of the stomach is slightly more frequent in men than in women (Warren), and occurs about the age of forty or later in life. The first symptoms are those of *indigestion*, with uneasiness in the stomach, irregular appetite, sometimes dull pain, constipation, loss of weight and strength, and sooner or later *vomiting* takes place. If the cardiac orifice is involved there is regurgitation within

from a few minutes to an hour after eating; if the pyloric orifice, vomiting may not occur for several hours after eating, there may be signs of dilatation of the stomach, and particles of food taken twenty-four hours previously are sometimes recognized in the vomitus. When ulceration takes place, the vomitus contains blood, which is usually dark in color, resembling coffee-grounds. Occasionally examination of this material or of the washings of the stomach reveals the presence of cancer tissue. The *hydrochloric acid* in the gastric juice is diminished or absent, and while not pathognomonic this is strong evidence in favor of cancer. Lactic acid and Oppler's bacillus are frequently found. Hydrochloric acid is absent also in other diseases of the stomach, as atrophy, amyloid degeneration, Addison's disease, pernicious anæmia, sometimes in phthisis and inflammatory conditions of the mucous membrane. In most cases the *tumor* can be felt at some time during the course of the disease. It is seldom perceptible before the third or fourth month, and is then detected in or near the centre of the epigastric region. It is usually movable, hard, irregular, and tender to pressure. As the disease progresses *pain* increases, there is rapid loss of flesh and strength and a marked *cachexia*. Metastases with secondary growths occur in the liver and other organs. Not all cases of cancer of the stomach have pain, vomiting, hemorrhage, and tumor; about 20 per cent. have little or no pain, about 10 per cent. have no vomiting, about half the cases do not vomit blood, and tumor is not perceptible in about 20 per cent. Examination of the *blood* shows a diminution of red corpuscles and hæmoglobin and absence of leucocytosis after a full meal.

Diagnosis.—The diagnosis must be made from *gastric catarrh*, diseases of the *gall-bladder* and *liver*, *gastralgia*, and *ulcer* of the *stomach*. The gastrodiaphanoscope may be used to detect a tumor in the anterior wall of the stomach. In doubtful cases an exploratory cœliotomy should be performed early in the disease, before it is too late to give the patient the benefit of a radical operation.

The *duration* of the disease, untreated, is from one to two years, death being due to general weakness.

Prognosis.—The only hope is in complete removal of the tumor, and this is impossible except in the earliest stages of the disease.

Treatment.—The treatment is *radical* or *palliative*. The radical operations are gastrectomy (removal of the entire organ) and pylorectomy, the former being indicated where the cancer involves the principal part of the stomach and the latter when it is limited to the pylorus. The *palliative* operations are gastro-enterostomy, or gastrostomy, to enable the patient to take and pass food.

OPERATIONS ON THE STOMACH.

GASTROPEXY is performed in cases of gastroptosis or Glénard's disease. Open the abdomen through the left rectus muscle and attach the centre of the anterior wall of the stomach to the anterior abdominal wall by two or three silk sutures which penetrate the peritoneal and muscular coats of the stomach and of the abdominal wall.

GASTRORRHAPHY, or GASTROPLICATION, is performed for dilated stomach without pyloric stenosis, in order to diminish the size of the organ. The stomach is folded on itself, so that the greater curvature is lifted up and attached to the lesser curvature by a row of sutures which pass through the peritoneal and muscular coats only.

GASTROLYSIS is the operation for freeing the stomach from adhesions which may have resulted from peritonitis.

GASTROPLASTY corresponds to pyloroplasty, and is sometimes performed for hour-glass stomach.

GASTROGASTROSTOMY means the establishment of communication between the two parts of the stomach which have been partially separated by hour-glass contraction. The operation is performed by making a large opening in each pouch below the contraction, and uniting them by two rows of sutures, or by means of a large Murphy button, as in case of gastro-enterostomy.

GASTROTOMY is performed for exploration, the removal of foreign bodies in the stomach or the lower part of the œsophagus, and for the treatment of stricture of the œsophagus or of either orifice of the stomach. Open the abdomen through the left rectus muscle by an incision from six to fifteen centimetres long through the skin, muscles, and sheath of the rectus to the transversalis fascia. Catch up the transversalis fascia and peritoneum with hæmostats on either side, and cut carefully between them to avoid wounding the viscera. If possible, draw a portion of the stomach outside of the abdominal cavity, and in any case carefully pack around with gauze before opening it. Make the incision in the direction to cause least hemorrhage,—parallel with the principal blood-vessels,—and promptly ligate bleeding vessels. Having accomplished the object of the gastrotomy, close the wound with two rows of silk sutures, about six to the inch, interrupted or continuous, the first passing through all the coats and approximating the edges of the incision; the second through the peritoneal and muscular coats, inverting the first row.

The first gastrotomy has been variously attributed to Mathias of Prague in 1602, and to Shoval in 1635.

GASTROSTOMY means making a more or less permanent opening in the stomach, through which the patient can be fed. The operation

is indicated in obstruction of the œsophagus or cardiac orifice of the stomach, which cannot be removed. The first gastrostomy was performed in 1849 by Sédillot.

Von Hacker's Operation.—Open the abdomen through the left rectus, draw out a cone-shaped fold of the stomach, attach the circumference of the cone to the parietal peritoneum and fascia, and the apex of the cone to the skin, by silk sutures. A small opening, just large enough to admit a No. 15 French catheter, may be made in the apex of the cone at once, or after the lapse of four or five days, when adhesions will have effectually shut off the peritoneal cavity.

The Ssabanajew-Franck Method.—Make an oblique incision parallel with and about half an inch from the left costal cartilages. Expose the rectus muscle and separate its fibres longitudinally. Open the peritoneum and draw out a cone-shaped fold of the stomach about one inch and a half long, and attach the circumference of the cone to the parietal peritoneum and fascia by silk sutures. Make a small incision through the skin about an inch above the costal margin, thrust a pair of hæmostats through the wound beneath the intervening bridge of skin, seize the apex of the cone, draw it through, and attach it to the skin of the upper wound. The lower wound is then closed. The stomach may be opened at once for the introduction of a rubber tube through which the patient is to be fed. This method is not apt to be followed by leakage, on account of the constriction produced by the rectus muscle and the firm support afforded by the costal cartilages when the dressing is applied. Occasionally the pressure produces erosion of the costal cartilages.

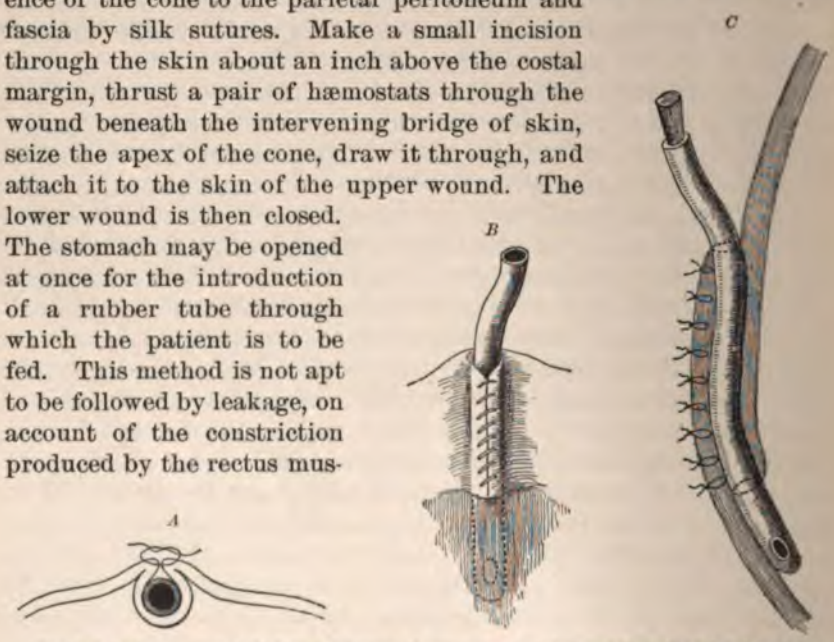

FIG. 237.—Witzel's method of gastrostomy: *A*, cross section of stomach-wall and tube, showing tube in place and enveloped by the walls of the stomach; *B* shows folds of stomach stitched over the tube,—dotted lines indicate the end of the tube in the stomach; *C*, longitudinal section, showing the tube lying in the canal,—outer end of tube closed with a stopper.

Witzel's Method.—Open the abdomen through the left rectus muscle by an incision at least seven centimetres in length. Draw the stomach outside of the abdomen if possible, and make an opening just large enough to admit a No. 25 French catheter in the anterior wall of the stomach near the greater curvature and the cardiac end. Introduce a soft-rubber catheter into this opening for about half an inch, fix it in the wound by a suture of catgut, and lay the portion of the catheter projecting externally against the anterior wall of the stomach so that the end projects through the upper angle of the abdominal wound. The catheter is then enveloped in the walls of the stomach for a space of two and one-half or three inches by taking a fold from each side and uniting the two over the catheter, the sutures passing only through the peritoneal and muscular coats. Restore the stomach to the abdominal cavity and stitch the stomach wall for a space of about one inch all around the catheter to the abdominal wall. Close the external wound, leaving the catheter projecting through the upper angle. After a week the catheter may be removed and inserted only at meal-times.

GASTRO-ENTEROSTOMY is the establishment of a communication between the stomach and the small intestine. The operation was first performed by Woelfler, and is indicated in obstruction of the pylorus, in some cases of pylorectomy, and in some cases of ulcer of the stomach.

FIG. 238.—Ligament of Treitz.

Von Hacker's Posterior Gastro-enterostomy.—Open the abdomen near the median line through the left rectus muscle between the ensiform cartilage and the umbilicus. Push the great omentum up out of the way, draw the transverse colon upward, and tear a slit in the mesocolon, opening the lesser peritoneal cavity and exposing the posterior wall of the stomach. Find the ligament of Treitz or the fixed part of the intestine at the duodenojejunal junction and select a point in the jejunum about sixteen inches below its origin for anastomosis. Turn it on its axis so that its peristaltic wave shall coincide in direction with that of the stomach, and unite it with the posterior wall of the stomach near

the greater curvature by means of a large Murphy button or by sutures. If sutures are used the stomach and intestine are held side by side and united for about two and one-half inches by a row of sutures passing through the peritoneal and muscular coats. Each organ is then opened by an incision about a quarter of an inch from

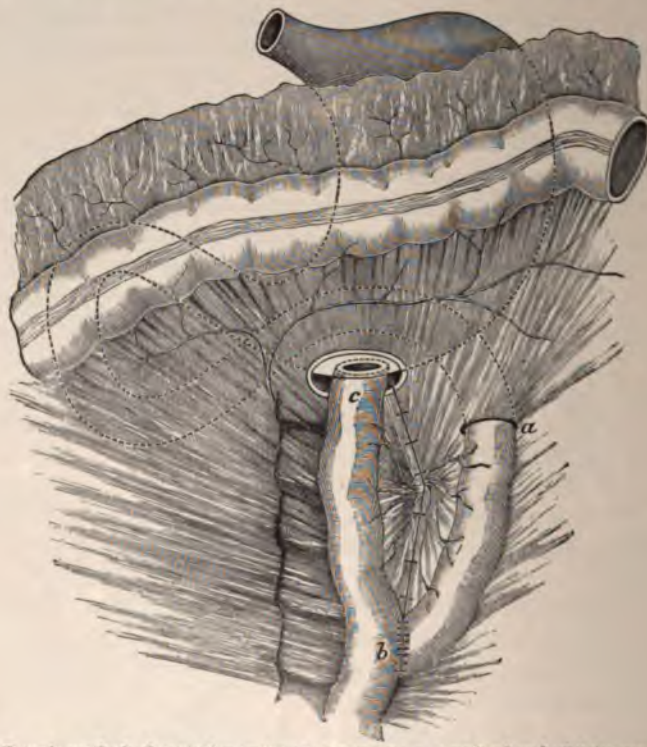

FIG. 239.—ROUX's method of posterior gastro-enterostomy: *a*, proximal end of jejunum; *b*, union of proximal and distal ends of jejunum; *c*, distal end of jejunum joined to stomach.

the line of sutures, assistants in the mean time holding them on each side to prevent escape of the contents, until the edges have been united entirely around the opening by sutures passing through all the coats. The first suture is then continued through the peritoneal and muscular coats until the circuit is complete.

In *anterior gastro-enterostomy* the intestine is united to the anterior surface of the stomach above the attachment of the great omentum. It is said to be more likely to result in the "circulus vitiosus,"—regurgitation of the duodenal contents into the stomach. To prevent this not only must the peristaltic wave of the stomach and intestine coincide in direction, but stagnation in the duodenum must be pre-

vented. This may be done by *Braun's method of entero-anastomosis* (the "combined method"), by which, in addition to the gastro-enterostomy, two points of anastomosis are made between different coils of the intestine, one uniting the intestine above the point of junction with the stomach to some distant coil below, and the other uniting the ascending and descending branches of the loop which anastomoses with the stomach; or by *Roux's method:* Expose the posterior part of the stomach near the pyloric end by an opening through the mesocolon, a little to the left of the vertebral column. Divide the jejunum six or eight inches below its junction with the duodenum. The distal end of the jejunum is brought up and implanted into the posterior surface of the stomach, while the proximal end of the jejunum is united by an end-to-side anastomosis with the jejunum at a convenient point well below the junction with the stomach.

PYLOROPLASTY, or the HEINECKE-MIKULICZ OPERATION, is performed in some cases of benign stricture. The pylorus is opened by a longitudinal incision, which also divides the stricture, and is then closed transversely. A better operation is *gastro-duodenostomy*, by which the stomach is united with the first part of the duodenum beyond and including the stricture, first dividing the stricture.

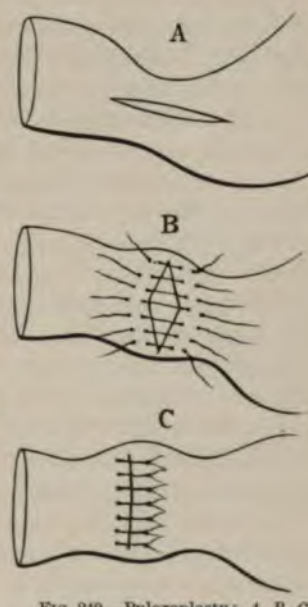

FIG. 240.—Pyloroplasty: *A*, *B*, *C*, first, second, and third stages of the operation.

PYLORECTOMY was first performed by Péan in 1879. It is indicated for the removal of malignant and other growths confined to the pylorus. *Operation:* As a preliminary measure wash out and empty the stomach. Open the abdomen through the right rectus muscle near the median line by a long incision extending from the ensiform cartilage downward. Examine the stomach carefully, and determine the extent of the disease. Draw the pylorus outside of the abdominal cavity if possible, and separate the greater and lesser omenta from the stomach and duodenum over a sufficient area by ligating on both sides and cutting between the ligatures. Clamp the duodenum with long forceps on each side of the site of the proposed division, and the stomach in the same way. Place gauze towels carefully to protect the peritoneal cavity before the next step of the operation, which consists in dividing the stomach and duo-

denum between the forceps. Remove the forceps from the stomach, while an assistant grasps it in such a manner as to prevent escape of contents. Close the end of the stomach by two rows of silk sutures, leaving an opening corresponding in size with that of the duodenum, with which it is then united. The duodenum should be joined to the stomach low down, near the greater curvature.

Pylorectomy combined with gastro-enterostomy may be preferred, especially if there is any difficulty in approximating the cut ends of the viscera. In this operation the stomach is closed completely and the end of the duodenum is attached to an opening made in the posterior wall of the stomach, by sutures or a Murphy button. The operation completed and all hemorrhage arrested, the exposed viscera are washed off with sterile salt solution, restored to the abdominal cavity, and the external wound closed without drainage. The patient's food should be entirely liquid for the first week.

The mortality of pylorectomy varies from 7 to 50 per cent.

GASTRECTOMY was first performed by Connor, of Cincinnati, in 1883, with a fatal result. The first successful gastrectomy was performed by Schlatter, of Zurich, September 6, 1897, the patient living over a year, then dying from recurrence of the disease. The indication for the operation is malignant disease, involving almost or quite the entire stomach, with the patient otherwise in good physical condition. *Operation:* Make an incision near the median line, from the ensiform cartilage to the umbilicus, and if possible deliver the stomach through the wound. Tie the greater, lesser, and gastrosplenic omenta in sections on both sides and divide them between the ligatures. Separate adhesions carefully and divide the œsophagus as low down as the disease will permit, between two pairs of clamped forceps; the duodenum is divided in the same way and the stomach removed. The end of the duodenum is then united to the œsophagus by two rows of sutures in the usual way or by a Murphy button. If there is difficulty in approximating the ends of the œsophagus and of the duodenum, close the latter by inverting the end and putting in a row of sutures; select a loop of jejunum which can be easily approximated to the œsophagus, bring it up in front of the transverse colon, and make an end-to-side anastomosis with the œsophagus by suture or Murphy button. The chief *dangers* of the operation are shock, hemorrhage, and peritonitis. In *feeding the patient* it is necessary to give food in small quantities, at short intervals. The *mortality* of the operation in selected cases is about 50 per cent.

SURGERY OF THE INTESTINES.

CONGENITAL ANOMALIES may exist in the form of *atresia*, constriction, diverticula, or double-tube. *Meckel's diverticulum* occurs in about 2 per cent. of persons; is caused by failure of the vitelline duct to become completely obliterated, leaving a projection from the lower part of the ileum varying in length from an inch to several inches, one end communicating with the intestine and the other ending in a blind extremity or cord, which may be free or attached to the umbilicus, the abdominal wall, the mesentery, other parts of the intestine; or the vitelline duct may remain open from the ileum to the umbilicus, giving rise to a congenital fecal fistula. This diverticulum is sometimes the cause of intestinal obstruction.

INTESTINAL OBSTRUCTION (ILEUS) may be complete or partial, acute or chronic, and may be caused by changes in its walls or by objects *within* the bowel, producing occlusion by filling its lumen, or by external conditions which may compress the intestine. *Acute obstruction* comes on suddenly, is accompanied by grave symptoms, and is apt to result in perforation, with peritonitis. In *chronic obstruction* the symptoms come on more slowly, with less severity, and if peritonitis occur it is more apt to be local in character. Obstruction may be caused by any of the following conditions:

1. *Fecal impaction*, or *coprostasis*, is a form of chronic obstruction, and is usually seen in old or insane persons or in those suffering from paralysis of the bowel. A mass of fecal matter accumulates in the rectum, the sigmoid flexure, or the cæcum, and occasionally the entire large intestine is filled. Stercoral ulcers may be produced by the hard mass, and even perforation, with peritonitis, may take place.

2. *Tumors and Strictures.*—Tumors may cause obstruction, either by mechanical action from their presence within or without the intestine or by infiltration of the intestinal walls, resulting in stricture. Carcinoma occurs most frequently in the sigmoid flexure or in the rectum; next, in the cæcum; but it may occur in any part of the intestine—sarcoma occurs most frequently in the cæcum. Stricture may also follow ulceration of tuberculosis, dysentery, or enteric fever.

3. *Foreign Bodies.*—These may have been swallowed or have ulcerated from other viscera, as gall-stones. *Enteroliths* are formed in the intestine; *avenoliths* contain oat-stones for a nucleus. (Treves.) In more than half the cases stones produce obstruction in the lower part of the ileum.

4. *Worms.*—Several cases of obstruction of the small intestine in children have been caused by masses of ascarides lumbricoides.

5. *Hernia.*—The ordinary forms of external hernia are not likely to be overlooked; but the rarer forms—obturator, ischiatic, perineal, and rectal—and the internal herniæ—diaphragmatic, through the foramen of Winslow, properitoneal, and hernia into the duodeno-jejunalis and intersigmoid fossæ—are difficult of diagnosis.

6. *Intussusception, invagination,* or *telescoping* results from the slipping of one portion of the bowel into the other, and causes nearly one-third of all cases of intestinal obstruction. In its simplest form an intussusception consists of two parts—the *intussusceptum* and the *intussuscipiens.* The *intussusceptum* is contained in the *intussuscipiens,* and consists of two parts, the descending and recurrent, with their peritoneal surfaces in contact. The *intussuscipiens* is composed of only one thickness of intestinal wall, with its mucous surface in contact with the mucous surface of the recurrent portion of the *intussusceptum.* The lumen of the intestine may be completely occluded by the intussusceptum and its mesentery; or the first intussusception may become invaginated into a second intussuscipiens so that the intussusceptum has five layers and even more. In nearly all cases the upper part of the intestine is received into the lower, and there may be more than one intussusception in the same individual. There are four varieties: The *ileocæcal,* in which the ileum with the ileocæcal valve passes into the cæcum and colon, the ileocæcal valve constantly forming the apex of the intussusception; the *enteric,* in which the small intestine is telescoped into itself; the *colic,* in which the large intestine is telescoped into itself; and the *ileocolic,* in which the ileum prolapses *through* the ileocæcal valve into the cæcum and colon without carrying the valve with it.

FIG. 241.—Intussusception.

The *causes* of intussusception are: *Age*—over half the cases occur in children under ten years of age, and it is most frequent during the first year of life, and in males; indigestion, with the production of strong peristalsis; a *tumor* attached to the interior of the intestine may start the invagination by its weight; and anything which produces a contraction of the one segment with relaxation of that immediately below, the longitudinal muscular fibres pulling the relaxed segment up over the contracted portion.

An intussusception varies in length from a few inches to several feet. Almost the entire colon may be invaginated with a large portion of the small intestine, and the cæcum has been known to project through the anus.

Termination.—Spontaneous cure may take place with sloughing of the *intussusceptum* and union of the *intussuscipiens* with the portion of the intestine just above the *intussusceptum*. The most prominent *symptoms* are a cylindrical or sausage-shaped tumor in the right iliac fossa or elsewhere, a protruding anal tumor, or the detection of a tumor in the rectum by digital examination, the passage of bloody stools with tenesmus, and other symptoms of intestinal obstruction.

7. *Volvulus* is the twisting of one or several loops of intestine, with torsion of only a small portion or of the entire mesentery. The intestine may be rotated on its own axis by the weight of an attached tumor, or two coils may be wound around one another so as to form a knot. It may occur in any part of the large or small intestine where the mesentery is sufficiently long to permit it, but is most frequent in the sigmoid flexure and in adult males.

FIG. 242.—Volvulus, with torsion of entire mesentery. (Author's case.)

The causes of volvulus are: A long mesentery, cicatricial contraction, traction caused by hernia, and excessive peristalsis from traumatism or indigestion.

Volvulus runs an acute course, and is apt to cause thrombosis of the mesenteric veins, with rapid gangrene of the intestine. In a case of the author's there was gangrene of over thirteen feet of intestine from torsion of the mesentery of less than twenty-four hours' duration.

The *chief symptoms* are: *Pain* in the left iliac fossa or in the umbilical region; localized tympanites from gas in the obstructed loop; an ill-defined tumor; constipation and vomiting, but there may be bloody stools or bloody vomitus; and bloody serum in the peritoneal cavity, which may be detected by rectal examination. When the sigmoid flexure is affected vomiting may not occur for several days.

8. *Bands and Diverticula.*—Obstruction or strangulation may be caused by adhesions between the omentum and other viscera, or between the intestines with one another or with other viscera, by attachment of the distal end of the vermiform appendix, or by Meckel's diverticulum, forming bands or openings into which a coil of intestine may slip and become constricted.

The *symptoms* are those of intestinal obstruction, the exact nature of which can be ascertained only after opening the abdominal cavity.

9. *Thrombosis* or *embolism* occurs in the mesenteric arteries or veins, and usually in men past middle age. The *causes* are, endocarditis, arteritis or plebitis, cirrhosis of the liver, hernia, or volvulus. The *symptoms* indicate intestinal obstruction and strangulation; as, abdominal pain, vomiting, tympanites, and the passage of offensive, bloody stools. The same symptoms occur in volvulus or intussusception.

10. *Adynamic ileus*, or *ileus paralyticus*, is the result of paralysis of the walls of the intestine. It may be *caused* by prolonged surgical operation on the abdominal viscera; injury of the nerve-supply; obstruction by adhesions, by distention of gas, or by sepsis or peritonitis.

11. *Dynamic ileus* is the reverse of adynamic ileus, and is caused by strong contraction of the circular muscular fibres, almost or completely obliterating the lumen of the intestine, probably from irritation of the nerves which control the circular muscular fibres.

General Symptoms of Intestinal Obstruction.—Pain, general in character or referred to the seat of obstruction, is always present, and if there be strangulation it is severe and colicky in character. *Vomiting* is nearly always present, and if the obstruction is near the stomach it is one of the first symptoms. It is most marked in strangulation. If the obstruction be in the lower part of the ileum or in the large intestine, the vomitus may be fecal in character. *Tympanites* is more marked when the obstruction is far from the stomach. In *volvulus* tympanites is often localized, confined to the loop involved, thus affording a valuable symptom of this condition. *Tumor:* In many cases of obstruction a tumor may be felt. In *cancer* or *sarcoma*, if perceptible, the tumor has a hard, elastic, nodulated feel, and would be found most likely in the right or left iliac region or in the rectum. The tumor of *fecal impaction* is found in the same regions or in any part of the large intestine. It gives a doughy or œdematous sensation on pressure. *Intussusception* gives a sausage-shaped tumor, elongated and firm to pressure, sometimes perceptible in the rectum. *Constipation:* In high obstruction the bowels may act several times and thus convey a false impression of the true condition. After evacuation of the intestinal contents below the obstruction constipation is absolute. There is little change in the *pulse* until sepsis or peritonitis occurs; then it becomes rapid—120 or more—weak and thready. The *temperature* is unreliable; it may be normal, subnormal, or elevated.

Diagnosis.—The diagnosis of intestinal obstruction is not difficult,

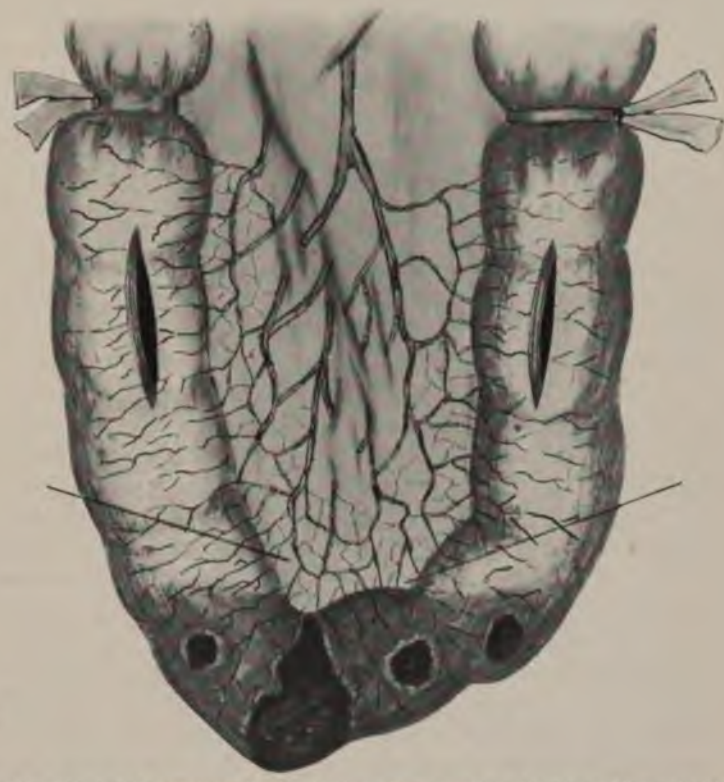

FIG. 243.—Side-to-side anastomosis of intestine after resection, showing oblique divisions of intestine, compression bands tied, lateral openings for joint, and patches of gangrene. (International Clinics.)

but it is not always easy to determine the cause. This is not so important, as in all cases of acute intestinal obstruction cœliotomy is imperative. Intestinal obstruction must not be confounded with pancreatitis, or poisoning by lead, arsenic, corrosive sublimate, etc.

Prognosis.—The great dangers in intestinal obstruction are *peritonitis* and *septicæmia.* If unrelieved, death generally results within ten days. Rarely spontaneous relief occurs by the formation of an external fistula, or a fistula between two portions of the bowel, or in intussusception by the sloughing away of the intussusceptum.

Treatment.—The patient can be made more comfortable by evacuating the stomach with the tube and the bowel by enemata. Do not give cathartics except in *fecal impaction* unattended by inflammation, when castor oil and oil of turpentine may be used in conjunction with high enemata. For *intussusception* try distention of the bowels with enemata of warm water during the first twelve hours, and if not relieved, perform cœliotomy. In other forms of obstruction or strangulation open the abdomen before it is too late,—before peritonitis sets in. Volvulus and hernia, if gangrenous, and cancer and sarcoma require resection of the intestine. In volvulus the mesentery must be untwisted.

In mesenteric thrombosis with gangrenous intestine remove the diseased portion of mesentery with the intestine. Impacted gallstones or enteroliths are removed by means of an incision through healthy gut above or below the point of impaction. If cœliotomy for fecal impaction be necessary, the intestine should not be opened, but the mass forced along by gentle, steady pressure.

INTESTINAL ULCERATION.—*Ulceration and Perforation in Typhoid Fever.*—Perforation is most frequent during the third week of the disease, but may occur in the second or fourth week, or even later. The *symptoms* are marked *leucocytosis* followed by pain more or less severe, collapse, and peritonitis—*tenderness; vomiting; tympanites,* often with disappearance of the liver dulness; *rapid, weak pulse; falling temperature,* which may afterwards rise; and sometimes an *anxious countenance.*

Treatment.—Open the abdomen without delay under cocaine or ether, through the right rectus muscle, and seek the perforation in the lower part of the ileum, the cæcum, the appendix, and the sigmoid flexure. When found, close the perforation without trimming. Numerous or extensive ulcerations may require resection of the intestine. If peritonitis exist, unless slight and limited, flush out the abdominal cavity and provide drainage.

Prognosis.—The mortality of one hundred and fifty-eight cases operated on was 76.59 per cent. (Keen). Joseph Price, in a personal

communication, reports twenty-three cases operated on, with twelve recoveries.

ULCERATION OF THE DUODENUM is a rare complication of burns on the surface of the body and of operations on the viscera, when it seems to be caused by an embolus plugging up a small artery and thus cutting off the blood supply to a limited area with resulting necrosis. Often no cause can be discovered. The *symptoms* and *treatment* are the same as in gastric ulcer. Of thirty-two perforated duodenal ulcers operated on, eleven recovered (Bolton Carter).

ULCERATION OF THE COLON, which has resisted other measures, may be treated by irrigation through a colostomy in the cæcum, or through the distal end of the vermiform appendix, which may be stitched to the skin and opened for that purpose, as suggested by McBurney.

APPENDICITIS—inflammation of the vermiform appendix—is a common disease.

Etiology and Pathology.—The *predisposing* causes are: *Age*—it being unusual at either extreme of life and most common between the ages of fifteen and thirty. *Sex*—it is four or five times as common

FIG. 244.—Swollen, thickened appendix, removed thirty-six hours after symptoms of appendicitis began.

in males as in females, the blood supply being greater in the latter. Its *position*—being outside the main fecal current and its small opening inviting the retention of foreign matter. Its *anatomy*—the mesentery being often too short, thereby causing a curve. And its *general lack of vitality*, owing to its rudimentary or vestigial character. Constipation, foreign bodies in the appendix,—coproliths, grape-seed, etc.,—traumatism, congestion from interference with its blood supply by twists or kinks, and previous attacks of the disease. The

exciting causes are the bacillus coli communis, alone or in conjunction with other bacteria, also the staphylococcus, streptococcus, and occasionally the tubercle bacillus. Examination of fifty cases showed the colon bacillus in forty-six and the streptococcus in fifteen,—often the two together. In twelve fatal cases the colon bacillus was found in seven and the streptococcus in three,—cultures taken at the time of

FIG. 245.—Appendix, showing perforation at *a*.

operation (J. J. Curry). When inflammation begins, the mucous membrane swells, narrowing the opening into the cæcum; the cavity of the appendix becomes distended with mucopurulent matter, the tissue breaks down in places, forming ulcers, superficial or perforating; or the entire appendix may be strangulated, causing gan-

FIG. 246.—Twist and kink of appendix caused by short mesentery. Fecal matter in lumen.

grene. Perforation may occur into the general peritoneal cavity, especially in gangrenous cases, but usually adhesions form a barrier which confines the pus to a limited area. The perforation may take place into the peritoneal cavity, the rectum, small intestine, bladder, or vagina; or pus may burrow behind the cæcum to the kidney, or

point near the anterior spine of the ilium or in the lumbar region. Acute gangrene of the appendix is generally due to thrombosis of the artery or vein, or both; or to the intense virulence of the micro-organisms. Often a concretion, usually of fecal material, bean- or olive-sized, is found. Not infrequently the cæcum is involved in the

FIG. 247.—Fecal concretion, with perforation at tip.

inflammatory process (typhlitis). In some cases the inflammatory process is limited, the symptoms soon subside or assume a subacute form, to recur again as a moderate attack, as an acute attack with localized peritonitis, or as a fulminating attack with gangrenous appendix, perforation, and probably general peritonitis. Chronic

FIG. 248.—Fecal concretion, with perforation near tip.

inflammation leads to the gradual destruction of the normal tissue and its replacement with fibrous tissue, the organ becoming small and impervious,—obliterative appendicitis. In some cases the appendix

is enormously enlarged by the production of an excessive amount of fibrous tissue. There is no doubt that one attack may result in apparent recovery and be followed by another after several years,—five years in one instance,—there being absolutely no symptoms of the disease in the interval. In the majority of cases the disease continues with exacerbations at intervals until the appendix is obliterated or destroyed by the inflammatory process, removed by the surgeon, or the patient dies.

Varieties.—All forms of appendicitis may be classified as *acute* or *chronic*, the acute form including *catarrhal*, *suppurative*, *perforative*, *gangrenous*, and *fulminating appendicitis*. The chronic form includes *recurrent*, *relapsing*, and *obliterative appendicitis*. It should not be forgotten that the chronic form is liable at any time to develop into one of the acute varieties.

Symptoms.—In the *acute* form, after a period of constipation,—rarely diarrhœa,—or some indiscretion in diet, there is a sudden attack of colicky *pain*, generally diffused over the abdomen, especially about the umbilical region, and finally located in the right iliac fossa. The pain is not always most severe on the right side; it may remain generally diffused, or may even be worse on the left side in cases where the appendix extends to the left of the median line. Frequent micturition, or pain during the process, indicates involvement of the vesicular peritoneum. The right thigh is usually flexed, to relax the psoas and iliacus muscles. *Tenderness* to pressure is especially marked over McBurney's point,—a point two inches from the anterior superior spine of the ilium on a line drawn from this spine to the umbilicus. Tenderness may also be elicited by digital examination by the rectum or vagina, and the appendix may be felt. *Rigidity of the rectus* and other abdominal muscles on the right side is present in the majority of cases. Sometimes the rigidity extends to all the abdominal muscles, especially if general peritonitis be present. *Vomiting* comes on with the pain, or a little later, and is probably present in 75 or 80 per cent. of all cases. *Tumor* or swelling in the right iliac fossa may be detected by palpation if a local abscess form or if the subjacent tissues become matted together by adhesions. In persons with thin and relaxed abdominal walls the swollen appendix can sometimes be felt. The *temperature* is elevated to 99½° to 102° F. or higher. In some cases the temperature is normal or subnormal. The *pulse* is increased to 100 to 120, and there is leucocytosis.

Appendicular colic and catarrhal appendicitis come on with sharp pains in the region of the appendix, with tenderness on pressure, usually accompanied by nausea and vomiting. The pulse and tem-

perature are not affected, or if so, very slightly. The symptoms may continue for from a few hours to two or three days, when they disappear, leaving a little soreness in the right iliac fossa. Unless the appendix is removed, other attacks are almost sure to follow.

Perforative and *gangrenous appendicitis* are indicated by grave *symptoms*, indicating collapse or septic poisoning. The *pulse* is weak and rapid, from 120 to 140. The *temperature* is often subnormal. The abdomen is swollen and tympanitic, or retracted and board-like. The skin is cold and covered with clammy perspiration. The *urine* may be suppressed, or is excreted in small quantity, and often contains albumin and casts.

In *chronic appendicitis*, if of the *recurrent* variety, after a more or less sharp attack the symptoms disappear, to return again after an interval of a month or longer. In *relapsing* appendicitis the patient is never entirely well after the first attack, but has digestive disturbances and pain, tenderness, or uneasiness in the region of the appendix.

Diagnosis.—*Gastritis* and *gastro-enteritis* (with acute indigestion) may be recognized by the more violent and persistent vomiting and by the absence of pain and tenderness in the region of the appendix. *Typhlitis*, or inflammation of the cæcum, except in connection with appendicitis, must be a very rare disease, the differential diagnosis of which would be extremely difficult. If accompanied by fecal impaction in the cæcum, the presence of a doughy tumor and the mild character of the symptoms point to typhlitis. In *biliary colic* the pain is at a higher point in the abdomen, in the epigastric region, or between the umbilicus and the chest, and is often felt in the right shoulder. There may be a history of previous attacks of jaundice or of the passage of gall-stones. *Renal colic*, or the impaction of a stone in the right ureter, is indicated by the location of the pain, its extension down the thigh or to the scrotum, frequent micturition, and the presence of blood or pus in the urine. A *floating kidney*, or tumors of the kidney, may be recognized by the movable character of the tumor and the absence of inflammation. *Typhoid fever*, especially walking cases, may lead to some confusion, but a careful history of the case with a Widal reaction will usually clear up the diagnosis. In women the diagnosis must be made from *ovarian* and *tubal affections* of the right side and from *cysts* and *ectopic pregnancy*.

Prognosis.—The mortality of appendicitis treated medically has been estimated to be from 12 to 15 per cent. With proper and timely surgical treatment this mortality could be reduced to 5 per cent. or less.

Treatment.—The ideal treatment would be to operate only on

those cases which are going to perforate, become gangrenous, or cause general peritonitis, septicæmia, or invalidism, and treat other cases medically; but unfortunately we can never say with certainty that the mild case of to-day may not be a gangrenous, perforative, fulminating case to-morrow. In all cases situated so that they can have competent surgical treatment and in which there are no contraindications, the appendix should be removed within twenty-four hours after the beginning of the attack. If for any reason it is decided not to operate in the early stage of the disease, the patient should be freely purged with sulphate of magnesium and cold application made to the seat of pain. If the symptoms do not improve within forty-eight hours, but are rather growing worse, with persistent vomiting, elevated or subnormal temperature, and rapid pulse, there should be no longer hesitation as to the necessity for operating. In perforation or in general peritonitis operation is imperative. Although the mortality in operations for general peritonitis is very high, from 65 to 90 per cent., in spite of the operation, it affords the only chance for the patient. If the *entire* peritoneum is inflamed, the case is probably hopeless under any form of treatment.

If a case is not seen until several days after the beginning of the attack, and the symptoms indicate convalescence, it is best to wait until recovery before operating, as the mortality of operations between attacks is much less than that of operations performed during the course of the disease, after the first twenty-four hours.

If an abscess form, it should be opened as soon as possible, taking care not to invade the general peritoneal cavity.

Operation.—There are three principal methods of making the incision through the abdominal wall,—namely, the muscle-splitting or "gridiron," the oblique (beyond the outer edge of the rectus muscle), and the incision through the right rectus muscle.

The *gridiron method* is preferred where it is probable that drainage will not be required,—for example, in the catarrhal form, when the operation is performed in the first stage, or in the interval of attacks. Make an oblique incision from two to four inches in length through the skin and external oblique muscle parallel with its fibres, the centre of the incision crossing McBurney's point. Retract the skin and external oblique on each side, bringing into view the fibres of the internal oblique, running transversely. Separate the fibres of this muscle, together with those of the transversalis beneath, as far as the sheath of the rectus. The transversalis fascia and peritoneum are then picked up with forceps and divided transversely in the same line. Insert the finger into the peritoneal cavity and search for the appendix, but do not break up adhesions until the abdominal

cavity has been protected by packing with long strips of gauze. If the appendix is not found just beneath the opening in the peritoneum, use a longitudinal band on the cæcum as a guide to the appendix. Draw the appendix through the opening until its mesentery and attachment to the cæcum are brought into view. Transfix and tie the meso-appendix, including the appendicular artery, as far as possible from the appendix, in one section if narrow, or in two sections if broad. The meso-appendix it divided, freeing the appendix as far as its origin from the cæcum. Before dividing the appendix, place gauze beneath it to prevent contamination of the peritoneum. Grasp the cæcum between the thumb and finger of the left hand just above the attachment of the appendix, remove the latter with knife or scissors on a level with the cæcum, and close the opening in the cæcum as if it were a bullet-hole,—namely, by two rows of continuous silk sutures, the first passing through all the coats of the intestine, the second inverting the first and passing only through the peritoneal and muscular coats. Arrest all bleeding. Unite the peritoneum and transversalis fascia with one row of continuous catgut sutures, the transversalis and internal oblique muscles by another, and the external oblique, superficial fascia, and skin by a third row of silkworm-gut sutures. Apply a dressing of sterile gauze, and put on a spica bandage around the right thigh and abdomen. Remove the external sutures about the tenth day, and if all goes well let the patient get out of bed in fourteen days. A spica bandage or abdominal supporter should be worn for two months.

The Oblique Incision.—The incision is nearly parallel with Poupart's ligament, its position being determined by the location of a tumor or by the supposed position of the appendix. If there is an abscess, the incision near the anterior spine may open it without involving the general peritoneal cavity. If so, the appendix should be sought with great care to avoid breaking into the peritoneal cavity; and, if not found, the abscess is drained and the removal of the appendix deferred to a more favorable time. When it is decided best to remove the appendix, and in those cases in which the incision opens the general peritoneal cavity, the abscess being situated just beneath, before breaking up the adhesions and evacuating the pus or searching for the appendix, the general peritoneal cavity should be protected by a wall of sterilized cotton in the shape of long strips packed around, above, to the inner side, and below the tumor. The adhesions are then broken up, the pus mopped up as rapidly as it escapes, and the appendix removed in the manner already described. After thorough cleansing of the abscess cavity by sponging and the cautious use of hydrogen peroxide, stuff it with iodoform gauze, re-

move the protecting gauze, and apply a dressing. In general peritonitis the abdominal cavity should be carefully irrigated throughout with salt solution and thorough drainage provided. The subsequent treatment consists in changing the iodoform packing every day, or every two or three days, until the pus disappears, when it may be removed and the wound allowed to close by granulation, or sutures may be introduced.

Incision through the Rectus Muscle.—Next to the gridiron method, this is probably the operation least likely to be followed by hernia. It is preferred in abscess unless situated near the anterior spine of the ilium; in general peritonitis; in cases in which the appendix extends across the median line; in females, to afford opportunity, if necessary, for dealing with ovarian or tubal trouble, and when plenty of room is wanted. The incision is made through the right rectus muscle parallel with its fibres, dividing all the structures in the same line.

Fecal Fistula.—A fecal fistula is an abnormal communication between the intestine and the surface of the body or an internal organ, such as the bladder, through which the bowel contents escape. Thus fecal fistula may be external or internal.

Causes.—It is not infrequent as a result of delayed operations for appendicitis, strangulated hernia, pelvic or abdominal abscesses, intestinal ulceration, foreign bodies in the intestinal canal, malignant tumors, and wounds. When all the contents of the intestine pass through the fistula, it is called an *artificial anus*. This is sometimes the result of a surgical operation to relieve obstruction of the bowels.

Treatment.—Small fistulæ usually heal without other treatment than keeping the parts clean and the bowels regulated. In larger openings, as in artificial anus, an operation is necessary.

Operation.—Empty the intestine above and below the attached portion and pack well with sterile gauze to prevent the escape of fecal contents during the operation. Open the abdomen far enough from the fistula to avoid cutting through diseased tissue. The nature of the internal operation is determined by the condition found inside. In case of a small opening with limited attachment of the intestine, make an elliptical incision externally, including a portion of the skin and muscles surrounding the fistulous opening, withdraw the coil of intestine, trim off the skin attachment, and close the opening in the intestine with two rows of silk sutures. The wounds in the abdominal wall are then closed in the usual way. In some cases with extensive adhesions it is best to make a lateral anastomosis, or to resect the portion of intestine affected and make an end-to-end anastomosis.

SURGERY OF THE RECTUM AND ANUS.

CONGENITAL MALFORMATIONS.—Failure of development may result in occlusion of the anus, or it may be represented by a minute opening; the anus may be well formed and yet end in a cul-de-sac; the rectum may be absent, the large intestine terminating above the sacrum, or it may open in the perineum, scrotum, urethra, vagina, or uterus.

Treatment.—Imperforate anus with a well-formed rectum is indicated by bulging of the parts. A crucial incision should be made through the obstructing septum, and kept patulous by the daily insertion of a bougie or the finger. If no trace of the rectum can be found after dissecting up the tissues for the space of an inch and a half, perform a left inguinal colostomy.

INJURIES.—Injuries of the rectum and anus may be the result of fracture of the pelvis, falls on a picket fence, or goring by an ox, etc. The *diagnosis* is made by the presence of hemorrhage, and sometimes the escape of the small intestine through the rent, or by examination with the finger or the speculum.

Treatment.—The treatment will depend on the nature and extent of the injury. After suturing lacerations, provide for free drainage, as it is impossible to maintain asepsis.

FOREIGN BODIES IN THE RECTUM may enter by the mouth or may be introduced through the anus, and may consist of fragments of bone, the seeds of fruit, sticks, stones, buttons, nails, hair-pins, etc. The *diagnosis* is easily made by examination with the finger or speculum, and the body is *removed* by means of a forceps or scoop with a bivalve speculum.

FECAL IMPACTION is often seen in paralytics, or in hysterical and insane persons. The *symptoms* are pain in the bowels with distention, a history of obstruction, and the mass is felt on rectal examination. The *treatment* consists in breaking up the hard mass and removing it by means of a spoon-handle or the fingers. Attempts may be made to soften and evacuate the mass by injections of warm water or glycerin and oil, after it has been broken up by means of an instrument.

FISSURE OF THE ANUS (IRRITABLE ANAL ULCER) is a form of ulceration, usually linear in shape, situated just within the margin, usually of the posterior border, of the anus, and involving the mucous membrane covering the sphincter.

The *cause* is probably the passage of a hard mass of fecal matter which produces a crack or abrasion of the mucous membrane, exposing the filaments of a nerve, with a resulting neuritis.

Symptoms.—A peculiarity of the condition is the severe pain,

which seems to be entirely out of proportion to the lesion. It is felt during and after defecation, and lasts for from a few minutes to several hours. Sometimes a small amount of *blood* or *pus* is discharged. The pain after defecation seems to be caused by spasmodic contraction of the sphincter (sphincterismus).

Treatment.—Recent cases can often be cured by keeping the bowels soluble, keeping the parts clean, and applying carbolized vaseline after each defecation. If this fail, apply cocaine and cauterize the ulcer with nitrate of silver or the actual cautery. In *chronic cases* give a general anæsthetic and paralyze the sphincter by stretching, or make an incision through the ulcer, dividing some of the fibres of the sphincter.

PROLAPSE OF THE RECTUM may be *partial* or *complete*. In *partial prolapse* the protruding portion consists only of the mucous membrane of the lower part of the rectum. It is sometimes called *prolapsus ani*. In *complete prolapse* or *procidentia recti*, the protruding portion contains all the coats of the rectum, sometimes even including the peritoneum. The rectum is turned inside out, or invaginated through the sphincter ani.

FIG. 249.—Prolapse of the rectum.

The *causes* are: Conditions which produce *straining*, *traction* on the *mucous membrane*, or *weakness of the sphincter ani*, especially in the very young and the aged, such as proctitis, constipation, worms, stone in the bladder, phimosis, polypi, enlarged prostate, and hemorrhoids.

Symptoms.—The condition is recognized by the protrusion of the anus—at first only after defecation, but later the protrusion may remain out continually and become swollen and ulcerated. *Complete* is distinguished from *partial* prolapse by its conical shape, its thick and firm walls, the orifice is slit-like, instead of circular as it is in partial prolapse, and the protrusion is much greater, sometimes reaching the length of six inches. The prolapsed portion may contain within its folds an ovary, a portion of the bladder, or a coil of small intestine.

Treatment.—Remove the cause, if possible. *Palliative treatment* consists in reducing the prolapse by placing the patient on the side or back, oiling the mass, and pressing with the fingers on the apex of the protrusion until it returns. A pad and T-bandage may be required

to prevent its return after reduction. The bowels should be evacuated with the patient in the recumbent position, at the same time the skin around the anus is pressed together or drawn to one side; a spindle-shaped tube may be worn in the rectum, or a tube may be introduced and gauze packed around it. *Radical Treatment.*—In *partial* prolapse and in mild *complete* prolapse, the protruded mucous membrane may be cut away with scissors, if small; cauterized with nitric acid; longitudinal folds may be excised by the clamp and cautery; or the cautery may be used alone, making from three to six longitudinal stripes through the mucous membrane on the surface of the tumor. The tumor is then reduced and kept in position, the bowels kept soluble until healing takes place, when the contraction of the scar tissue will cure the trouble. In *complete* prolapse amputation or colopexy is required.

Amputation.—Make a transverse incision about one inch below the sphincter through the outside wall of the protrusion, introduce the finger and ascertain if a coil of intestine or other viscus is involved. Suture together the two walls of the prolapsed intestine all the way around by means of a curved needle with silk thread and amputate just below the sutures. Then unite the ends of the mucous membrane, reduce the stump, and keep in place by one of the methods already given. In cases in which the sphincter is very much dilated and weak, remove a V-shaped portion, including a portion of the posterior wall of the rectum, and unite the wound by sutures.

Colopexy.—Open the abdomen by an incision about three inches long, on the left side, about an inch above and parallel with Poupart's ligament. Pull up the intestine until the prolapse is completely reduced, and hold it in position until the anterior longitudinal band can be stitched to the margins of the wound by five or six silk sutures.

HEMORRHOIDS or piles are tumors composed of dilated or varicose veins of the anus and lower part of the rectum. There are two principal varieties—the *external* or blind, and the *internal* or bleeding. The *external* variety develops below the external sphincter muscle either as a tag of skin or skin and mucous membrane with hypertrophied connective tissue; or it is a varicose condition of the external hemorrhoidal veins which may contain a blood clot (hæmatoma). *Internal piles* develop above the external sphincter muscle in connection with the middle and superior hemorrhoidal veins and arteries. There are two kinds: The *venous*, composed of dilated or varicose veins, connective tissue, and mucous membrane, forming a good-sized mass; and the *capillary* or *nævoid*, containing capillaries, arteries, and veins (angiomata), of a bright red color and situated high up, with a tendency to bleed.

The *causes* are: *Middle age, heredity,* and conditions which interfere with the return of the venous blood from the rectum, as the erect position of man; the absence of valves in the veins; constipation; pregnancy; obstruction to the portal circulation; or straining from any cause.

FIG. 250.—Internal hemorrhoids.

The *diagnosis* can be made without difficulty if the piles protrude, one or more red or purplish tumors being visible, or they may be brought into view by making the patient bear down. At other times they may be detected by examination with the finger in the rectum, or an anæsthetic may be given and an examination made with the speculum. Hemorrhage in nævoid piles is sometimes profuse and persistent. Often the irritation extends to the bladder, producing frequent urination or retention. Polypus, prolapsus, ulceration, and cancer must be excluded.

Treatment.—Remove the cause, regulate the diet and habits, and prevent or cure constipation. The use of alcohol and excessive eating should be avoided. In *external* hemorrhoids, if inflamed, put the patient to bed, give a cathartic, apply heat or cold, as may be agreeable to the patient, and use suppositories of opium, belladonna, and cocaine. In case of *hæmatoma*, inject cocaine, incise the tumor, turn out the clot, and pack with gauze. Tags of skin may be cut off with scissors, and tumors may be excised by making two short skin-flaps, which are closed over the wound after excision. *Internal* hemorrhoids may be treated locally by suppositories or injections of soothing and astringent medicines, such as opium, belladonna, cocaine, alum, and witchhazel, and adrenalin may be tried. If prolapse of the tumors occur, they should be reduced by anointing them with oil or vaseline and pressing gently with the finger until they are pushed beyond the sphincter. The *radical* method consists in the removal of the hemorrhoids by the *ligature*, the *clamp and cautery*, or *Whitehead's operation*. The treatment by injections of carbolic acid is not recommended. Prepare the patient for operation by the administration of a brisk cathartic on the day before, and an enema on the morning of, the operation. Anæsthetize the patient, place him in the lithotomy position, and paralyze the sphincter by introducing the two thumbs and sepa-

rating them to a sufficient extent. Balls of absorbent cotton or gauze, with a strong thread attached, should then be packed in the rectum, above the field of operation, to prevent interference by discharges from that quarter.

The Ligature.—If the tumors are not visible a speculum should be used. Grasp the tumor with a pair of ring forceps, make slight

FIG. 251.—Sims's rectal speculum.

traction, and divide with scissors the mucous membrane around the base of the tumor. A strong silk thread, doubled, is then passed by means of a needle through the base of the tumor, the needle cut off, and the threads separated and tightly tied in two sections. The ligature is cut short and the pile cut away, leaving only sufficient tissue to prevent slipping of the ligature. This process is repeated until all the hemorrhoids have been excised. A suppository containing one grain of opium and half a grain of cocaine is introduced into the rectum, and a dressing of gauze and cotton applied, and held in place with a broad T-bandage. *Retention of urine* occasionally occurs after the operation. The *after-treatment* consists in keeping the patient in bed for a week and the bowels soluble by the use of laxatives.

FIG. 252.—Kelsey's pile clamp.

The Clamp and Cautery.—The pile is drawn down with ring forceps, the clamp applied to its base and screwed up tightly, and the part projecting above the clamp is burned off with the Paquelin cautery. Hemorrhage is more apt to follow the use of the clamp and cautery than the use of the ligature.

The Whitehead Method.—This consists in removing the pile-bearing portion of mucous membrane. Make an incision around the anus, just *within* the mucous membrane, and dissect up a cuff of mucous membrane with the hemorrhoidal tumors from the subjacent coat to a point a little above the limit of the hemorrhoids. Remove the cuff of mucous membrane containing the piles, bring down the remainder, and suture it to the edge of the mucous membrane below by catgut or silk.

RECTAL ABSCESS may be *superficial* or *marginal* and *deep*. The *superficial* abscess occurs just beneath the skin about the margin of the anus, and on careless examination may be mistaken for hemorrhoids. If not opened early it may burrow beneath the skin and produce superficial fistulæ. *Deep rectal abscess* may be *supralevator* and *ischiorectal* or *sublevator*.

The *supralevator* abscess occurs in the space above the levator ani muscle and beneath the peritoneum. The *symptoms* are pain and uneasiness in the pelvis, with rectal or vesical tenesmus. If not opened, the pus may break into the bladder, vagina, rectum, peritoneal cavity, or point externally in the groin or back. The *treatment* consists in early incision through the ischiorectal fossa and levator ani muscle, or through a point of fluctuation, should one be present.

The *ischiorectal* abscess is formed in the ischiorectal fossa below the levator ani muscle. The causes are: Contusions; penetration of the rectal wall from within by fragments of bone; abrasions by indurated fecal matter, seeds of fruit; a general debilitated condition; and inoculation of the part with pathogenic organisms—not infrequently the tubercle bacillus. *Acute abscess* is caused by infection with one of the obligate pyogenic germs.

Symptoms.—Ischiorectal abscess is most common in middle life, and is often attended with constitutional symptoms—*chill* and *fever*. *Pain* of a heavy throbbing character is felt on one side of the rectum, and is increased during defecation or coughing. On examination there is *tenderness* on pressure and the skin may be *hard*, *red*, and *brawny*. Sometimes there is no change in the skin, but on introducing the finger into the rectum a marked *swelling* can be felt on one side. If left alone the abscess ruptures into the rectum, or externally near the anus, or in both places, often leaving a sinus—known as *fistula in ano*.

Treatment.—On the appearance of the first symptoms of the trouble make a free incision through the skin into the ischiorectal fossa, break up the septa between the different pockets of the abscess cavity, curette, irrigate with bichloride solution, stuff with iodoform gauze, and renew the packing at intervals of two or three days until suppuration ceases.

FISTULA IN ANO may be *complete* or *incomplete*. The *complete variety* is one in which the tract extends from the cutaneous surface without to the mucous surface of the rectum. The *incomplete* or *blind variety* is subdivided into the *blind internal fistula*, in which there is an opening into the rectum but none on the skin, and the *blind external fistula*, in which there is an opening on the skin but none on the mucous membrane of the rectum.

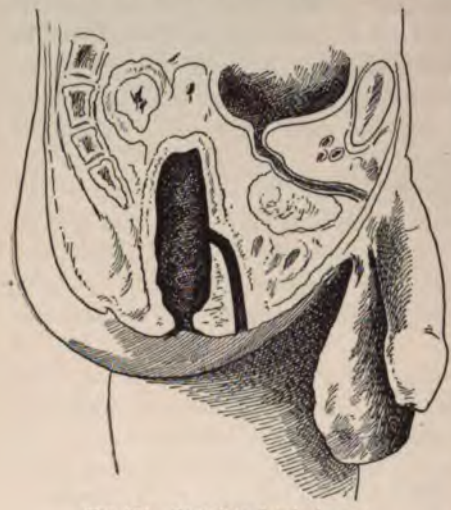

FIG. 253.—Complete fistula in ano.

A horseshoe fistula may be *complete* or *incomplete*, and is one in which the tract extends in a semicircle in front of or behind the anus. It may have one or two external and the same number of internal openings.

Usually the internal opening of a fistula is within an inch of the anus, but occasionally the opening may be above this point, and the pus cavity may extend considerably above the point of opening. The external opening is usually on one side, within half an inch to three inches from the anus, but it may be in the perineum or posteriorly, and there may be several openings, — internal or external, — and a single internal opening may communicate with several external ones. An external opening sometimes communicates with an internal opening on the opposite side of the rectum.

FIG. 254.—Blind external fistula in ano.

Causes.—Fistula is always the result of a rectal abscess and is often tuberculous.

Symptoms.—*Complete* fistula is easily recognized. There may be slight *tenesmus*, a little *blood* in the stools, and a constant discharge

of a small amount of *pus*—sometimes of *gas* and *fecal* matter. On examination a small external opening is detected, into which a probe should be gently introduced as far as it will go. After introducing the probe, and not before, pass the finger into the rectum and feel for the point of the probe at the internal opening. When the probe fails to detect the internal opening, it may be found by injecting some colored fluid, or peroxide of hydrogen, through the external opening and observing through a speculum the point at which it enters the rectum. In *blind external* fistula examination with the probe or by injection of fluids fails to detect an internal opening. In *blind internal* fistula there are usually *pain*, sometimes *induration* and *swelling* about the anus, which disappear after a discharge of *pus* from the bowel. With these symptoms examine the patient carefully under anæsthesia by introducing a speculum and searching for an opening with a bent probe in the lower part of the bowel.

FIG. 255.—Blind internal fistula in ano.

Treatment.—A few cases of recent fistulæ recover as a result of curettage, the use of nitrate of silver, and cleanliness. Most cases, however, require an operation.

Operation.—The bowels are evacuated by a cathartic the day before the operation and cleaned out with an enema on the morning of the operation. After anæsthesia place the patient in the lithotomy position, or on one side, as may be preferred. Introduce a grooved director through the fistula into the rectum, and pull the point out through the anus by the finger. If the fistula be *incomplete*, make it *complete* by thrusting the grooved director through the mucous membrane into the rectum, or by an incision through the skin, as the case requires. Divide the bridge of tissue held upon the director and curette or dissect out the tract, and pack the wound with iodoform gauze. Communicating branches are searched for, slit up, and curetted, but do not divide the sphincter ani in more than one place, for fear of incontinence. When there are two or more internal openings on opposite sides, it may be best, as suggested by Kelsey, to

do two or three operations at intervals, lest the recuperative power of the patient be endangered. The after-treatment consists in keeping the bowels soluble, avoiding constipation, and renewing the packing every day or two, later twice a week until healing occurs. In some cases of simple fistula the entire tract may be excised and the wound sutured with good results, but in the majority the best results follow packing the wound. Two or more operations may be required before effecting a cure.

Fecal incontinence following operation for fistula should be treated by removal of the scar tissue and suture of the ends of the sphincter muscle.

STRICTURE OF THE RECTUM may be *simple* or *malignant*. Malignant stricture will be considered under tumors of the rectum. *Simple stricture* is more common in women than in men, may be congenital or acquired, and in shape annular or tubular. Its usual location is from an inch to an inch and a half, or between four and six inches, above the anus.

Causes.—Stricture may be due to tumor, abscess, adhesions, or to ulceration from wounds, tuberculosis, syphilis, chancroid, proctitis, chronic constipation, and, rarely, dysentery, or gonorrhœa.

Symptoms.—The patient has alternating attacks of diarrhœa and constipation, straining at stool, and the passage of abnormally small, irregular masses stained with mucus and blood. As the disease progresses abscess or fistula may form. Death may result from complete obstruction of the bowels, from perforation, from peritonitis, or from exhaustion due to suppuration and long-continued suffering.

The *diagnosis* is made by examination with the finger or with the rectal speculum. If the stricture is situated high up, a condition of "ballooning" (Bryant) is often found, in which the rectum below the stricture is enormously dilated. The hand, if less than seven inches in circumference, may in some cases be introduced into the rectum for examination. Malignancy can be excluded by the history of the case, its long duration, the age of the patients,—most of them being under middle age,—the absence of a hard, nodulated growth and of involvement of the sacral lymphatic glands.

Treatment.—Internal incision is suitable in case of congenital stricture, the incision being made through the posterior part of the rectum and kept open afterwards by the use of bougies. *Dilatation* by soft-rubber bougies, passed daily, may be tried when the stricture is not very tight and is situated within easy reach. The bougies are gradually increased in size until full dilatation is obtained. *Linear proctotomy* may be performed for strictures situated low down, in which dilatation has failed. The sphincter is dilated, the patient anæsthe-

tized, placed in the lithotomy position, and a free incision is made through the posterior wall of the rectum and sphincter from a point just above the stricture to the tip of the coccyx. The wound is packed with iodoform gauze and allowed to heal by granulation, bougies being used subsequently to prevent contraction. *Resection and Excision.*—Resection is the best operation if dilatation be unsuccessful, provided the stricture be located above the sphincter muscle. The rectum is exposed by a Kraske or other suitable incision, the stricture cut out, and the upper end of the rectum brought down and stitched to the lower end. In cases involving the sphincter, excision may be required. *Colostomy* may be resorted to when none of the preceding methods are suitable and in cases in which it is important to give immediate relief to obstruction of the bowels.

TUMORS OF THE RECTUM AND ANUS.—The most common *benign* growths of the rectum are the various polypi—adenoma, fibroma, or papilloma—which are often seen in children. The *malignant* tumors are carcinoma, and, rarely, sarcoma.

Cancer of the rectum may be scirrhus, encephaloid, or colloid, squamous epithelioma, or cylindrical epithelioma, the latter variety being the most common. When cancer begins in the anus, it is always of the squamous variety. Cylindrical epithelioma commences in the epithelium lining the follicles of Lieberkuhn. The growth may be located principally in the mucous membrane, causing early ulceration, and extending to the subjacent tissues; or it may begin in the deeper portions of the mucous membrane, forming a tumor in the walls of the rectum, projecting into the bowel, and not ulcerating until a later period. The tumor at first occupies a limited portion of the circumference of the tube, but as it increases in size it may extend almost or completely around it, and stricture is produced.

FIG. 256.—Adenocarcinoma of the rectum.

Symptoms.—It is found with about equal frequency in both sexes, and usually in persons past forty years of age, but not infrequently it occurs in persons much younger, even in children. While often insidious in its onset and not discovered until it has attained considerable size, it usually begins with diarrhœa, hemorrhage, more or less pain, tenesmus, and the discharge of pus and mucus, often mixed with blood. As the growth increases, symptoms of stricture come on,

with constipation, small, ribbon-shaped fæces, and when ulceration takes place the pain becomes severe. Fistula sometimes results, leading to adjacent organs—as the bladder or vagina. If complete obstruction takes place, there is enormous distention of the abdomen and other symptoms of intestinal obstruction. Œdema of the lower extremity may be caused by pressure on the iliac vein. Death from metastasis, septicæmia, or exhaustion usually occurs, in from one to three or four years, but it may occur at any time from peritonitis as a result of perforation.

The *diagnosis* is made by digital examination, or by the use of the speculum; by the history of the case; by the nodulated, rough sensation given to the finger; the marked tendency to bleed; involvement of the sacral lymphatic glands, which may be felt through the rectum; the fixed character of the growth, and even of the rectum itself; the patulous condition of the anus which is often seen; and the rapid growth of the tumor.

Treatment.—The treatment is *palliative* or *radical*. *Palliative* treatment is indicated when there is no chance of cure, and consists in the use of opium for the relief of pain, or in making an inguinal colostomy to relieve intestinal obstruction. *Radical treatment* consists in complete removal of the diseased tissue. *Resection of the rectum* is performed as follows: A preliminary colostomy may be first performed. After the patient has recovered from this, say three weeks, he is prepared for the operation of resection by washing out the rectum. If the growth is less than four inches from the anus it may be removed without excising the coccyx or part of the sacrum. Place the patient on one side and make an incision from the tip of the coccyx to the margin of the anus, if necessary enlarging it by extending it along the side of the coccyx and to one side of the anus. Free the rectum from its attachments, avoiding the bladder, urethra, and vasa deferentia in front, and in the female the vagina; pull it down and divide it an inch above and an inch below the tumor. Arrest bleeding, unite the ends of the gut by a double row of sutures, partially close the external wound, and pack it lightly with iodoform gauze. In the female the rectum may be resected through the posterior wall of the vagina. *Another method* is to open the posterior wall of the rectum and divide the sphincter by an incision from the tip of the coccyx; pull down and resect the rectum, unite the ends, and sew up the slit in the posterior wall, including the sphincter.

The modified Kraske operation is suited for tumors situated four inches or more above the anus. Make an incision from the middle of the sacrum to the posterior margin of the anus, detach the soft parts from the lower part of the sacrum and coccyx, and remove

them by dividing the bone with a chain saw or chisel just below the third sacral foramen. Tie the sacral artery, free the rectum high up, even into the peritoneal cavity if necessary, bring it down, resect and unite it, and if possible close the opening in the peritoneum by sutures. Partially close the external wound and pack it lightly with gauze, as primary union often fails to occur and a fecal fistula is apt to develop at the point of anastomosis, which may heal spontaneously or require a second operation to close it.

Levy's method does not extirpate the bones, and consists in making an osteoplastic flap composed of the soft tissues and the lower part of the sacrum and coccyx. A horseshoe-shaped incision is made from a point just within the tuber ischii on one side across the lower third of the sacrum to a corresponding point near the other tuber ischii. The sacrum is divided below the third foramen, as already described, and the flap, composed of bone and soft tissue, is turned forward over the perineum. After removing the growth and making the anastomosis, the cavity is packed with iodoform gauze and the osteoplastic flap is placed back in position, but is not sutured until union of the intestinal ends has taken place.

Extirpation of the Anus and Rectum.—The Perineal Method.—Make an incision from the tip of the coccyx around and including the anus, going well outside of the tumor. Open the ischiorectal fossæ, divide the attachments to the levator ani muscles, free the rectum, bring it down, remove the diseased parts, and suture the end of the intestine to the skin, or to the tissue just above the skin, in the normal position of the anus.

Extirpation of the anus and rectum may also be done by the *modified Kraske operation*, as described above, stitching the end of the rectum to the skin just below the stump of the sacrum.

OPERATIONS ON THE INTESTINES.

COLOTOMY AND COLOSTOMY.—*Colotomy* means the making of a temporary opening in the colon. *Colostomy* means the making of a more or less permanent opening in the colon. *Colostomy* may be *anterior* (iliac) or *posterior* (lumbar); in the former the cæcum and sigmoid flexure are opened in front through the peritoneal cavity and in the latter the intestine is opened from behind external to the peritoneal cavity. The *indications* for colostomy are: Imperforate anus, benign or malignant stricture of the rectum, a rectovesical fistula, and ulceration of the rectum or colon as a result of colitis or proctitis.

Anterior iliac or *inguinal colostomy*, first done by Littre, is generally to be preferred, as the opening is more accessible and convenient to the patient. It may be done on either side.

Maydl's Inguinal Colostomy.—Make an incision three or four inches in length, parallel with Poupart's ligament, at a point one-third the distance from the anterior spine of the ilium towards the umbilicus. Split the muscular fibres, as in the gridiron operation for appendicitis. Open the peritoneum, draw out the highest part of the sigmoid flexure until a glass rod or tube can be thrust through its mesentery, thus preventing the loop from returning to the abdominal cavity. Suture together the two limbs of the intestine on each side, below the rod, and then stitch the projecting loop to the skin all around the opening. Open the gut immediately, or if the symptoms are not urgent, wait until adhesions have taken place. If the opening is to be *temporary*, divide the intestine only partially, or make a longitudinal opening. Keep the rod in place until it is desired to close the opening, when the rod is removed and the intestine allowed to drop back, the opening often closing without further treatment. If not, an operation for fæcal fistula can be made. If *permanent*, divide the bowel completely, remove the rod, and stitch each end of the intestine to the skin. Cripps advises the stitching together of the peritoneum and skin as a preliminary step of the operation. When the opening is made on the right side, the glass rod cannot be used, and the cæcum or ascending colon should be stitched to the margins of the wound by a double row of sutures.

Posterior or lumbar colostomy may be performed on either side. *Amussat's Method.*—Make a four-inch incision one inch below and parallel with the last rib, from the edge of the quadratus lumborum muscle forward and downward. Divide the lumbar fascia, expose the kidney fat, and find the colon uncovered by peritoneum in front and a little to the outer side of the kidney. It is distinguished from the peritoneum by its longitudinal bands, by its contents, by its thicker walls, and when possible to pass the stricture, by its becoming distended with water injected through the rectum. Withdraw the colon far enough to form a spur, to prevent the lower segment from filling up with fecal matter, open it by a longitudinal incision, and stitch the edges to the margin of the skin. A pad kept in place by a broad bandage must be worn.

ENTEROTOMY AND ENTEROSTOMY are operations on the small intestine corresponding with colotomy and colostomy on the colon. They are performed for the removal of foreign bodies, for the evacuation of intestinal contents in cases of obstruction, or when a gastro-enterostomy or a colostomy is impracticable.

ENTEROPLASTY is an operation on the intestine corresponding to pyloroplasty on the stomach.

ENTERECTOMY, or RESECTION, is the operation by which a sec-

tion of the intestine is removed, the ends being united by one of the various methods of anastomosis. Enterectomy may be *complete* or *incomplete*, the incomplete operation consisting in excising a portion of the circumference of the bowel opposite the attachment of the mesentery. Enterectomy is *indicated* in gangrene of the intestine; in obstruction due to tumor or stricture which cannot otherwise be removed; for the cure of certain fæcal fistulæ; and for the removal of severely damaged intestine as a result of traumatism.

The mortality from enterectomy depends on many factors,—the occasion for the operation, the condition of the parts, and the skill of the operator. There were fifty-eight deaths following two hundred and twenty-six enterectomies with immediate union for gangrenous hernia (Gibson). Ten feet seem to be the limit to the amount of intestine which can be removed and the patient survive in good health.

Operation.—Draw out the intestine, strip back the contents beyond the points at which it is to be divided, and give into the hands of assistants, who hold the intestine between the fingers, making just sufficient pressure to prevent the escape of contents. Protect the abdominal cavity by means of pads or towels of gauze. Divide the intestine with knife or scissors through sound tissue, well above and below the diseased portion. Divide the mesentery about half an inch from the intestine, parallel with it, unless diseased, when a V-shaped portion should be removed. Arrest all hemorrhage and unite the ends of the intestine by some method of anastomosis. The cut edges of the mesentery are brought together and united by a row of Lembert sutures on each of its surfaces, approximating the serous surfaces and burying the cut edges of the mesentery.

INTESTINAL ANASTOMOSIS is the joining of two portions of intestine in such manner as to restore the continuity of the lumen. Anastomosis may be *end-to-end*, *end-to-side*, or *side-to-side*, and may be accomplished by *suture alone* or by some *mechanical device* with or without suture. The *end-to-end* anastomosis is preferable when practicable. The *end-to-side* method may be preferred when a segment of small calibre is to be attached to one of much greater size. The *side-to-side* method is used especially when resection is impossible or undesirable, the offending part being side-tracked or excluded—as in extensive adhesions with or without malignant growths.

Means of Making Anastomosis.—Their name is legion,—at least seventeen kinds of suture and twenty kinds of mechanical device having been recently described,—but only a few of the most practical will be given.

Sutures.—The Lembert suture, devised in 1825 by Lembert, may

be continuous or interrupted. The needle is passed in and then out on each side of the intestinal wound at a slight distance from the margin, so as to approximate the peritoneal surfaces, the edges of the wound being turned in. This suture penetrates the serous and muscular coats, but not the mucous coat of the intestine.

The Czerny-Lembert Suture.—In this method the edges of the wound in the intestine are first united by sutures which penetrate all the coats, after which the Lembert suture is inserted, inverting the first row of sutures and approximating the serous coats. This description of the Czerny-Lembert suture is not the one given by many authors, but it is the most practical, and is certainly in general use.

The Connell Suture.—In this method the knots of the sutures are all placed on the mucous membrane within the lumen of the intestine, and the serous surfaces are approximated by a single row of sutures which pass through all the coats of the intestine. The suture is introduced in a circular enterorrhaphy as follows: The cut ends of the intestine are placed side by side, parallel with one another, and the needle is introduced from the mucosa on one side through all the coats of both walls, into the lumen of the other side. It is then reversed, traversing all the coats of both walls, and the suture is tied on the mucous surface whence it started. This is repeated until the ends of the intestine have been united for two-thirds or more of their circumference; the remaining third is united by a continuous suture. Beginning where we left off, "the needle after having entered the lumen is passed on the same side one-eighth inch distant; then over to the opposite cut end, where it is inserted from without in, and again emerges from within out on the same side. This step, the taking of a bite, is repeated alternately on the opposing margins until the necessary number of stitches have been inserted. It will be observed that when the needle enters the lumen the last time it makes what might be termed a half-stitch, as it does not return again through the wall, but having reached the point where the suture was commenced, the free end of thread and the needle end will complete the last stitch on the mucosa. The needle at this point is then brought out of the lumen at the angle of the wound alongside of the free end of the suture. The cross-over stitches are next carefully drawn up, thus bringing into contact the opposing serous surfaces at every point except where the suture ends still protrude." The eye end of a threaded needle is then inserted between any of the sutures on the opposite side of the intestine and pushed through to the point where the ends of the suture project. These ends are passed through the loop formed by the thread in the eye of the needle, and the needle is withdrawn, bringing with it the suture ends, which are

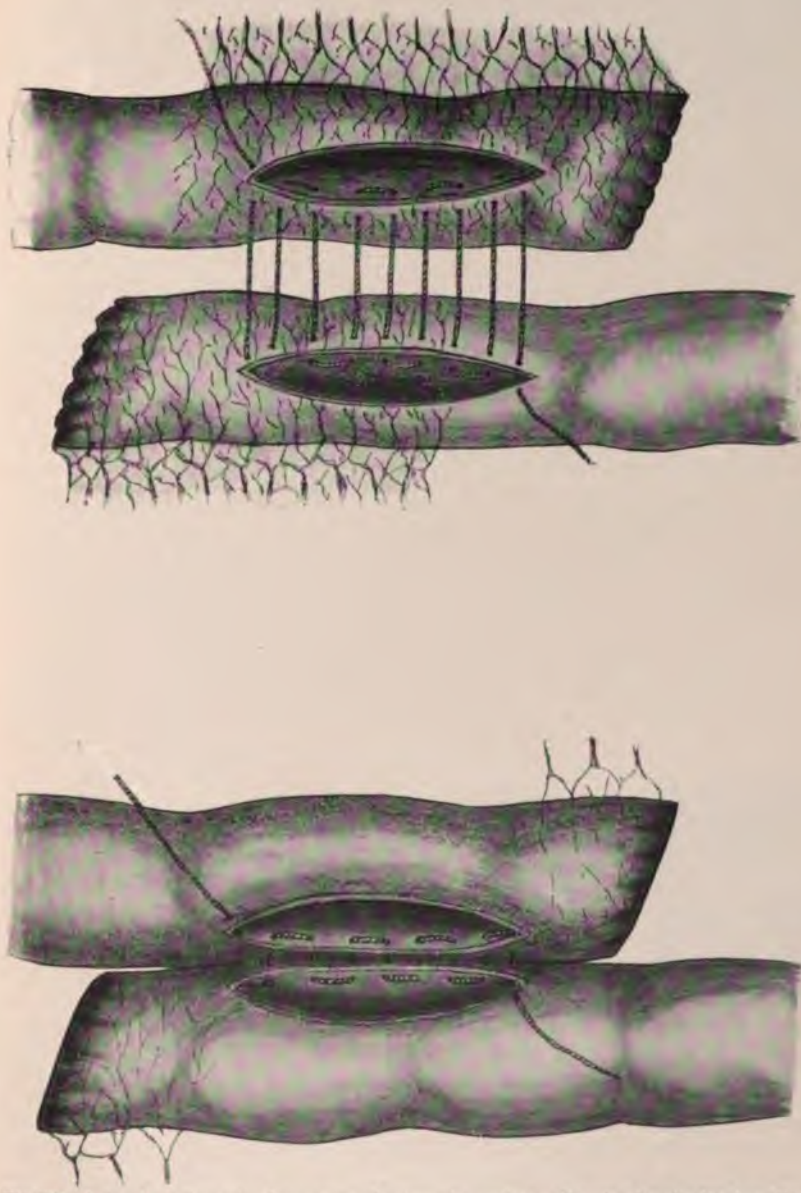

FIG. 257.—Lateral anastomosis. Lower row of sutures in position. Showing longitudinal continuous suture and mesenteric vessels intact to base of divided bowel. (International Clinics.)

then tied firmly while the intestine is compressed so as to bring the opposite walls close together. The knot is then pushed between the stitches where it was tied and rests on the mucous coat. *The split-end method* is performed as follows: The ends of the segments to be united are split at a point opposite the mesentery for a distance equal to the circumference of the intestine. This permits them to be spread out as two flat ribbons which are placed with their serous surfaces together, and united by sutures passing through all the coats, about the eighth of an inch from the ends. The intestine is then permitted to resume its normal tubular shape, and the long slit on its convex border is closed by a continuous row of Lembert sutures. *Maunsell's method* is the best of the invagination methods. The ends of the bowel are united at two opposite points by two sutures whose ends are left long. A longitudinal slit is then made in the intestine, about one inch above the junction, through which the long ends of the two sutures are withdrawn. By pulling on these sutures the two ends of the intestine are drawn through the slit already invaginated, with their serous surfaces approximated. Sutures are inserted, the bowel drawn out, and the slit closed. The objection to the last two methods is the longitudinal slit, which adds further injury to the intestine, and the closure of which diminishes its calibre.

Mechanical Devices.—The simplest and best mechanical device is the *Murphy button*. The chief objections to the Murphy button are that the orifice may become obstructed or the button itself may

FIG. 258.—Murphy's anastomosis buttons. Longitudinal section.

lodge in the intestine or stomach. The button consists of two parts, each of which is provided with a hollow shank, one of which fits into the other, so that when pressed together the two portions remain in position, while the opening through the button permits the flow of the intestinal contents if they are liquid. The button is used as follows: A purse-string silk suture is introduced close to the end of the intestine in an end-to-end anastomosis, or close to the margin of the slit in the side of the intestine in a lateral anastomosis. One-half

of the button is seized firmly by the shank with a pair of hæmostats and inserted into the intestine, the purse-string suture tied firmly around the shank, and the end of the intestine carefully pressed into the groove of the button at the base of the shank. The other half of the button is fixed in a similar manner into the other end of the intestine. The hæmostats are then, and not until then, removed, and the two parts of the button pressed together, bringing the serous surfaces of the intestine into firm contact. The junction may be reenforced by a row of Lembert sutures; but this is not necessary if the approximation has been accurately made. Adhesions take place between the portions of the intestine around the circumference of the part compressed, the compressed part sloughs, releasing the button, which is usually passed from the rectum in from two to four weeks after the operation.

Laplace's Forceps.—Laplace's forceps resemble two pairs of hæmostats in which the jaws have been bent so as to form two rings in four segments. The forceps are used as follows: The two ends of the bowel to be united are brought together by four sutures at equidistant points; the forceps are introduced between any two of the sutures, opened, the ends of the intestine pressed between the rings, and the forceps closed and clamped. One or two rows of Lembert sutures are introduced, the clamp removed, the forceps withdrawn, one-half at a time, and the opening through which they were withdrawn closed by an additional stitch or two. The advantage of this method is that it leaves nothing which may act as an obstruction; but it requires some skill to use the forceps.

Inflated rubber cylinders, first used by Treves and others, and recently revived by Halsted, may be used to aid circular enterorrhaphy. The rubber cylinder is hollow and communicates with a tube attached midway between its two ends. The cylinder is inserted into the two ends of the intestine to be united, and is then inflated with air through the tube; sutures are introduced, the cylinder removed after letting out the air, and the opening through which it is removed closed by sutures.

Choice of Methods.—With an experienced operator simple union of the parts by the Czerny-Lembert or Connell suture is the best method, as it leaves no foreign body to irritate or cause obstruction, and the operation can be rapidly performed without the aid of any mechanical device. With an inexperienced operator—and especially if there is necessity for great haste—the use of the Murphy button is the best method.

HERNIA.

Hernia is the protrusion of any viscus into or through the walls which normally confine it; but, unless otherwise specified, it means the escape of some part of the intestine, or of the omentum, through the abdominal walls or into a compartment of some kind.

General Anatomy.—As a rule, a hernia is composed of a *sac* and *contents*. The sac is a pouch of peritoneum continuous with the parietal peritoneum of the abdominal cavity. It is usually flask-shaped, and the narrow or constricted portion, where it passes through the limiting walls, is called the *neck*, and the large portion beyond, the *body*. The *contents* are usually bowel or omentum, or both, although all of the abdominal viscera have at various times been found in the hernial sac. In recent cases the hernial sac is very thin,—just the thickness of the peritoneum and fascia,—while in old cases it may be a quarter of an inch or more in thickness.

ETIOLOGY.—*Heredity*, with congenital defects. *Age:* No age is exempt; according to decades, the largest number occur during the first, and probably the next decade most fruitful of hernia is between twenty-five and thirty-five. *Sex:* Hernia in general is four times, and inguinal hernia from six to nine times, more frequent in the male; while, on the other hand, femoral hernia is two and one-half times, and umbilical hernia about five times, more frequent in the female. *Occupations* requiring great muscular effort, and *diseases* requiring straining, as bronchitis, stricture, constipation. The principal *exciting cause* is *traumatism* of the abdominal wall as the result of straining, a surgical operation, etc.

FREQUENCY.—It has been estimated that from 6 to 12 per cent. of the human race suffer from hernia (Marcy), about 90 per cent. being of the *inguinal* variety, 2½ per cent. *femoral*, the other varieties amounting to 7½ per cent.

VARIETIES.—According to the time of appearance, hernias may be *congenital* or *acquired*. These terms are also used in inguinal hernia to indicate the relations of the intestine to the peritoneum. According to situation, hernias may be divided into *external* and *internal*.

The *external* hernias are: Inguinal, femoral, umbilical, ventral, ischiatic, lumbar, obturator, and perineal.

The *internal* hernias are: Properitoneal, retroperitoneal (into the fossa duodeno-jejunalis, the ileocæcal, or sigmoid fossa), into the foramen of Winslow, and diaphragmatic.

According to their conditions *clinically*, hernias may be: Reducible, irreducible, inflamed, obstructed or incarcerated, and strangulated.

According to *contents*, hernias are called enterocele, epiplocele, cystocele, rectocele, etc.

INGUINAL HERNIA is a protrusion into or through the inguinal canal. It is by far the most common form of rupture, and is more frequent in males in the proportion of nine to one. Inguinal hernia may be *oblique* or external, and *direct* or internal. It may be *unilateral* or *bilateral*, and is more frequent on the right side. It is further

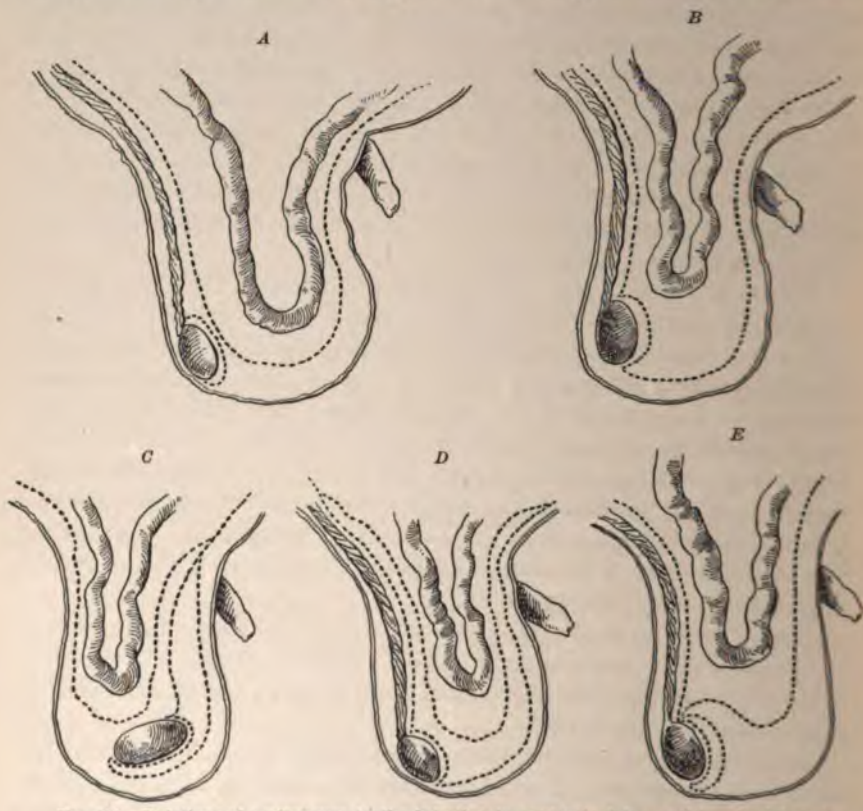

FIG. 259.—Relations of peritoneum to the intestine in anatomical forms of inguinal hernia: *A*, ordinary acquired hernia; *B*, congenital hernia; *C*, infantile hernia; *D*, encysted hernia; *E*, hernia into the funicular process. (Modified from Gray.)

divided, according to the relations of the intestine to the peritoneum of the tunica vaginalis and funicular process, into: Acquired, congenital, infantile, encysted, and hernia into the funicular process.

An *oblique inguinal* hernia is one which passes through the inguinal canal, along with the spermatic cord or round ligament, to the scrotum or labium. It is also called *external* because it passes to the outer side of the epigastric artery.

Direct inguinal hernia enters the inguinal canal by bursting through or pushing in front or to one side of it the conjoined tendon passing through Hesselbach's triangle to the inner side of the epigastric artery; hence it is called *internal* inguinal hernia.

The coverings of an *oblique* inguinal hernia from without to the intestine are: The skin, superficial fascia, intercolumnar fascia, cremaster muscle, infundibuliform fascia, and peritoneum.

The coverings of *direct* inguinal hernia are: The skin, superficial fascia, the intercolumnar fascia, cremaster muscle (possibly the conjoined tendon), transversalis fascia, and peritoneum.

FIG. 260.—*a*, Oblique inguinal hernia; *b*, direct or ventro-inguinal hernia; both having descended into the scrotum.

Common or *acquired* inguinal hernia passes through the inguinal canal, pushing a process of peritoneum before it, and descends into the scrotum in front of the spermatic cord and testis, but does not enter the tunica vaginalis.

Congenital hernia is that form in which the pouch of peritoneum (funicular process) which accompanies the cord and testis in their descent remains open throughout, instead of becoming obliterated between the tunica vaginalis and the point where it leaves the general peritoneum. The intestine descends into this pouch and is in contact with the testis, having no proper sac but that of the tunica vaginalis.

Infantile hernia is that form in which the pouch of the peritoneum is closed at the internal ring but remains open throughout the rest of its extent. The intestine pressing against the peritoneum carries it down into the scrotum behind the funicular process so that in front of the bowel there are three layers of peritoneum,—two layers of the funicular process and the sac of the hernia.

The *encysted* variety somewhat resembles infantile hernia, the funicular process being closed at the internal ring, but pressure by the intestine at the point of occlusion causes a stretching of the peritoneum and the formation of a sac which projects down into the funicular process and tunica vaginalis.

Hernia into the funicular process is that form in which the intestine descends into the open mouth of the funicular process but does not enter the tunica vaginalis, the funicular process having been

obliterated at the top of the testis but not at the internal ring. In this form the intestine has no proper sac, simply that formed by the funicular process.

An incomplete inguinal hernia—that is, one which has not emerged from the inguinal canal—is called *bubonocele*.

If the hernia, after passing the inguinal canal, enters the scrotum, it is called a *scrotal hernia*. In the female it enters the labium, and is called a *labial hernia*.

FIG. 261.—Large double scrotal hernia.

In the congenital variety of inguinal hernia, in the female the bowel protrudes into the canal of Nuck, the process of peritoneum which surrounds the round ligament.

Diagnosis.—Examine the external ring by introducing the finger, and compare it with the other ring and ascertain if anything besides the cord passes through it. If the epigastric artery can be felt by the finger in the canal, direct and oblique inguinal hernia can be distinguished, the neck of the former being to the inner side, that of the latter on the outer side of the artery. Direct hernias are always acquired. In old oblique hernias the prolonged pressure and dragging often bring the internal ring down to the same level with the external ring, so that one ring lies directly behind the other, the inguinal canal having been obliterated.

Inguinal may be distinguished from *femoral* hernia by its position nearer the median line, by being able to grasp the neck of the sac where it emerges from the external ring, and noticing in some cases the prominence in the inguinal canal.

In *femoral* hernia the neck of the hernia can be felt in the saphenous opening below Poupart's ligament, a little to the inner side of the femoral artery and vein. If the spine of the pubes can be felt and the hernia lies to its inner side, it is *inguinal*; if to the outer side, it is *femoral*. Femoral hernia is usually small, while inguinal is often very large.

Hydrocele is dull on percussion, gives no impulse on coughing, is translucent, unless bloody or in a black scrotum, usually cannot be

reduced, and on grasping the cord at the external ring no hernial neck is felt. *Congenital hydrocele* may be recognized by the symptoms above given, by its slow disappearance when the patient lies down, and its slow return, filling from the bottom of the scrotum when the patient stands up. *Hydrocele of the cord* is more difficult to distinguish. When hydrocele and hernia co-exist, each may be distinguished by its peculiar characteristics.

Varicocele could scarcely be mistaken for hernia on careful examination. The dilated tortuous veins seen through the skin, a sensation as of a bag of worms, the disappearance of the tumor in the recumbent position, and its reappearance in the erect position, although the finger may be kept in the external ring, are enough to distinguish it from hernia.

Undescended testicle may be recognized by its absence from the normal position, by its firm sensation, and by the nausea occasioned by pressure.

The urinary bladder is not infrequently found in the hernial sac with the intestine.

FEMORAL HERNIA.—In femoral hernia the intestine pushes the peritoneum in front of it through the femoral ring and canal, escaping

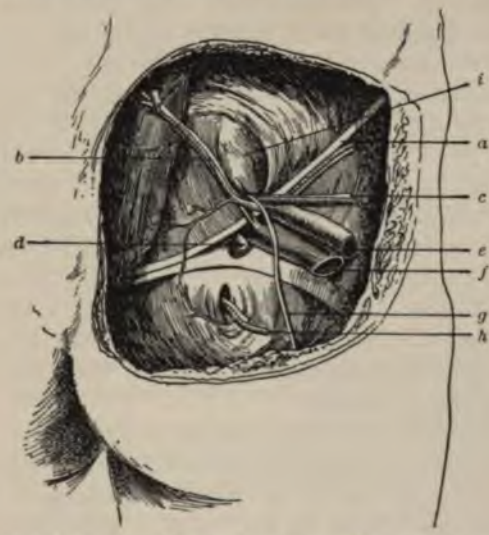

FIG. 262.—Relations of femoral and inguinal hernia, seen from within: *a*, Poupart's ligament; *b*, epigastric vessels; *c*, spermatic vessels; *d*, femoral ring; *e*, external iliac artery; *f*, iliac vein; *g*, vas deferens; *h*, obturator artery; *i*, internal abdominal ring. (Modified from Gray.)

at the saphenous opening, whence it turns upward and inward, and may occupy very nearly the position of an inguinal hernia, but the

neck of the hernia can be felt at the saphenous opening. The coverings from without in are: Skin, superficial fascia, cribriform fascia, the femoral sheath, septum crurale, and peritoneum. To the outer side of the sac is the femoral vein. Femoral hernia is always acquired, and is most frequent in females, in the proportion of two and a half to one, and rarely occurs before adult life. It is much more liable to become strangulated than inguinal hernia, and the mortality from strangulated femoral hernia is much greater than that from strangulated inguinal hernia.

Diagnosis. (See INGUINAL HERNIA.)—*Psoas abscess*, and *varix of the saphenous vein* can be distinguished by careful examination. *Enlarged lymphatic glands, fatty tumors, and cysts* may be mistaken for strangulated or irreducible femoral hernia, and often the diagnosis is impossible without operation, especially when the presence of these tumors or glands is associated with vomiting and constipation. Both the hernia and an inflamed gland or tumor may be present at the same time.

UMBILICAL HERNIA.—Umbilical hernia is that form in which the intestine leaves the abdominal cavity through the navel. It is more common in females, in the proportion of about five to one, and may be *congenital* or *acquired*. The *congenital* variety is due to arrested development of the abdominal walls, and the spleen and liver, as well as the intestines, are sometimes found in the sac. In some cases the hernia is contained in the umbilical cord, and the intestine may be injured when the cord is cut. The *acquired* variety may be *infantile* or *adult*. The great majority of umbilical hernias belong to the *infantile* group, and are caused by the stretching or giving way of the cicatrix at the umbilicus. *Umbilical hernia in adults* is usually seen in fat women beyond thirty years of age, may be very large, and often contains omentum adherent to intestine. Such hernias are often irreducible and liable to inflammation and obstruction or incarceration. The coverings of an umbilical hernia are frequently fused together and so attenuated by pressure that they ulcerate and allow escape of the intestines.

VENTRAL HERNIA.—Ventral hernia is that form in which the intestine protrudes through the anterior abdominal wall in any other position than through one of the natural openings. The openings are most frequently found in the middle line between the recti muscles, but may occur anywhere, as the result of wounds following surgical operations or other injuries. A subvariety of ventral hernia is known as epigastric hernia. This occurs in the linea alba or near it, or in the lineæ semilunares between the umbilicus and the ensiform cartilage.

ISCHIATIC OR GLUTEAL HERNIA is an unusual form of hernia, in which the intestine with its sac escapes through the greater or lesser sacrosciatic foramen, either above or below the pyriformis muscle. It is covered by the gluteus maximus muscle, but sometimes escapes beneath its lower border, when it may be recognized beneath the skin. The contents of the sac may be intestine, omentum, ovary, or bladder.

LUMBAR HERNIA is a rare form of hernia which comes through Petit's triangle, a weak spot just above the crest of the ilium which forms its base, the two sides being formed by the external oblique in front and the latissimus dorsi behind. The *causes* are traumatism or abscess from caries of the spine. It is more common in adults and in males.

OBTURATOR HERNIA.—This variety of hernia protrudes through the obturator foramen following the canal occupied by the obturator vessels and nerves. It pushes before it or breaks through the obturator fascia and obturator externus muscle to the under surface of the pectineus muscle, and may appear as a swelling well to the inner side of the femoral vessels just below the inner end of Poupart's ligament. It is more frequent in women, and when appearing externally may be mistaken for femoral hernia or for tumor or abscess. Examination by the vagina or rectum may aid in the diagnosis by detecting a coil of intestine fixed to the obturator foramen.

PERINEAL HERNIA occurs, in the majority of cases, in adult women, the intestine pushing through the levator ani muscle into the ischiorectal fossa and appearing beneath the skin in the perineum. Sometimes the protrusion is into the rectum, pushing it towards or through the anus, or, in the female, into the vagina or the posterior part of the labia majora (pudendal hernia).

INTERNAL HERNIAS.—PROPERITONEAL OR INTERSTITIAL HERNIA may be of three varieties: The *first*, in which the sac lies between the peritoneum and abdominal muscles; the *second*, in which the sac lies between the external and internal oblique muscles; and the *third*, in which the sac is found between the skin and the external oblique. These forms may attend inguinal, femoral, or umbilical hernia. The cause is most frequently the result of an attempt to reduce a hernia by taxis, but it may be caused by the obstruction of an undescended testicle. The *symptoms* are those of intestinal obstruction, and such a hernia should be suspected when after apparent reduction of an external hernia there is no relief of the symptoms.

RETROPERITONEAL HERNIA.—In this form of hernia the intestines form a sac by pushing the peritoneum of one of the fossæ downward behind the parietal peritoneum. It may occur in one of three places:

Either at the fossa duodeno-jejunalis, in the region of the cæcum, or of the sigmoid flexure.

HERNIA INTO THE FORAMEN OF WINSLOW.—This is a rare form of internal hernia, in which the intestines enter the lesser peritoneal cavity through the foramen of Winslow.

DIAPHRAGMATIC HERNIA nearly always occurs on the left side and may be *congenital* or *acquired*. The congenital form is due to a defect in the diaphragm. The stomach or intestines or a large portion of the abdominal contents may project into the thoracic cavity. The *acquired* form is probably due to traumatism, to stab or gunshot wounds, or to rupture of the diaphragm from crushing injuries.

Symptoms.—In the *congenital* form the condition may not be discovered until a necropsy is made. In the *acquired* form the symptoms are: Great dyspnœa; rapid, weak, and perhaps irregular action of the heart and displacement of the heart to the right; tympany and absence of respiratory sounds over the lower half of the left lung, and in hernia of the stomach a gurgling, tinkling, or splashing sound in the lower part of the thorax, accompanied by nausea and vomiting.

The *treatment* consists in opening the abdomen, reducing the hernia, and, if possible, closing the opening in the diaphragm by means of sutures.

PARTIAL HERNIAS.—RICHTER'S HERNIA is that form in which only a part of the circumference of the bowel is engaged in the hernial opening, and occurs most frequently at the femoral ring. The *symptoms* are usually those of intestinal obstruction or strangulation, though there may be no interference with the passage of intestinal contents.

LITTRE'S HERNIA is that form of hernia in which the contents are a Meckel's diverticulum—an exceedingly rare occurrence.

CLINICAL VARIETIES OF HERNIA.—REDUCIBLE HERNIA is one which can be returned to the abdomen by means of taxis or posture without operation. IRREDUCIBLE HERNIA is one which cannot be reduced without operation. INFLAMED HERNIA is local peritonitis of the intestine in the hernial sac. It may occur in irreducible hernias which have been subjected to prolonged taxis or contusion and pressure from a truss. OBSTRUCTED or INCARCERATED HERNIA is one which is imprisoned and the passage of the intestinal contents is interrupted, but the circulation of blood remains undisturbed. The *cause* is most frequently the accumulation of fecal matter in the loop of bowel, but it may be a constriction which is tight enough to close the lumen of the bowel without producing strangulation. It occurs most frequently in umbilical and inguinal hernias in elderly persons. The *symptoms* are those of indigestion, anorexia, and a

feeling of discomfort in the abdominal region, or pain of a colicky nature, with nausea and vomiting, while the hernia is larger and tenser than usual.

STRANGULATED HERNIA.—When a hernia is so tightly constricted that the circulation of the blood is seriously hindered, it is said to be *strangulated*. It is also irreducible, obstructed, and incarcerated. It is most common on the right side, and is most liable to occur in femoral hernia, and may be caused by severe muscular efforts, especially in old hernias and in elderly persons—sometimes in hernias on their first occurrence.

Pathology.—The usual site of the constriction is outside the neck of the hernial sac where the tissues are firm and unyielding, as at the internal or external abdominal rings or at the femoral ring. The constriction may be in the hernial sac, caused by adhesions or by the existence of volvulus, twists, or the crowding into the sac of additional intestine or mesentery. The venous circulation is partially arrested, leading to congestion, swelling, and inflammation of the imprisoned loop; and as the swelling increases, the constriction becomes tighter until the venous circulation is completely arrested, then that of the capillaries and arteries. There is an exudate of serum,—first clear, but later bloody and turbid or dark in color. The intestine is blue from the congestion, then dark red, changing to a black or grayish color when gangrene has taken place. The intestinal walls are thickened from infiltration of serum. The peritoneal coat loses its smooth, glistening surface, and becomes dull or rough on the surface. The entire loop of intestine contained in the sac may become gangrenous and separate at the point of constriction, leading to the formation of an artificial anus; or there may be one or more small areas of gangrene in the loop which break down under pressure with perforation of the intestine. Sometimes the hernial sac is involved in the gangrene. Gangrene may occur in from four to twenty-four hours, or it may be delayed several days, depending on the degree of obstruction of the circulation.

Symptoms.—The symptoms usually come on suddenly, soon after the descent of an old hernia or the occurrence of a new one, or after some muscular effort, the patient being seized with colicky pain, coming on in paroxysms and most severe about the hernia; but frequently it is referred to the umbilicus, which is often the seat of the greatest pain; *vomiting*, immediately or shortly after strangulation begins, which may become stercoraceous if the obstruction is in the lower ileum; *complete constipation* after the bowels have been emptied below the point of obstruction; somewhat elevated *temperature* in the early stages, but later it may be normal or subnormal;

and variable *pulse*, sometimes corresponding with the temperature, at other times it may be rapid and weak—120 or more—while the temperature is subnormal. The urine is diminished in quantity. There is usually great prostration. Cessation of pain, with persistence of vomiting, rapid pulse, and subnormal temperature, means the occurrence of gangrene, which may be followed by cold extremities, sunken features, collapse, and death—usually in from five to seven days.

The *local* symptoms are a tense, tender, irreducible tumor, without impulse on coughing, sometimes resonant, but later becoming dull on percussion from effusion of serum.

Very rarely spontaneous recovery ensues with the formation of an artificial anus, the surrounding tissues becoming inflamed and finally ulcerating and giving exit to the contents of the sac. If the strangulated part is composed only of omentum, the symptoms are not so severe, the vomiting is not so frequent, constipation may not exist, and the degree of prostration is not so great.

The *diagnosis* is made from *obstructed* and *inflamed* hernia by loss of impulse on coughing, the sharp character of the pain in the early stages, the extreme tension and tenderness of the tumor, the persistent vomiting, and the marked constipation. In all cases of doubt an exploratory incision should be made.

Treatment of Hernia.—The treatment of hernia is divided into *palliative* and *radical*.

Palliative treatment includes the reduction of the hernia and the use of some mechanical appliance, as the truss, to keep it from coming down.

Taxis is the process of manipulation used to induce a hernia to return into the abdominal cavity. Place the patient in the posture most favorable to the relaxation of the tissues about the hernial ring, in the Trendelenberg position to get the aid of gravity, and anæsthetize him to produce relaxation of the parts. Take the tumor in the right hand and its neck between the thumb and forefinger of the left hand in order to guide the intestine aud prevent bulging when it is pressed against the edges of the ring. Return first the part which descended last by coaxing the neck of the tumor with the left hand while pressure is gently but firmly made with the right hand on the body of the tumor. In *femoral* hernia flex the thigh and rotate it slightly inward in order to relax the fascia lata which bounds the saphenous opening. Always make pressure in the line of the hernial canal; in *oblique* inguinal hernia, backward, outward, and upward in the line of the inguinal canal; in *direct* inguinal hernia, straight back; and in *femoral* hernia, first downward till

brought opposite the saphenous opening, then backward and upward. When successful the hernia slips into the abdomen, often with a "gurgle" or "croak."

Contraindications to taxis are inflammation, peritonitis, gangrene, or strangulation of a hernia.

Dangers of Taxis.—Too forcible or prolonged taxis may cause rupture of the bowel or sac, or contusion which may be followed by peritonitis. Gangrenous bowel may be returned. A properitoneal hernia may be formed, or the hernia may be reduced *en masse* or *en bloc*, with the strangulation unrelieved.

The Truss.—The most common variety of truss is composed of a spring which encircles the patient's body, to one end of which is attached a pad made of wood, rubber, or other material which fits over the hernial opening. Other supports are used for special forms of hernia. In infants a hank of worsted may be used in the form of a spica passing around the thigh and the body and crossing over the site of the hernia, where it is knotted. In children the persistent use of the truss often results in cure.

Measurements for a truss should be made from the hernial opening to the anterior superior spine of the ilium on that side, then around the body one inch below the crest of the ilium across the other anterior superior spine to a point a little above the hernial opening. The truss should be constantly worn, except when the patient is in bed. It should be removed after lying down and put on before getting out of bed, the object being to prevent the hernia from at any time coming down. In some cases it is best for the patient to wear a light truss while in bed.

The Radical Treatment of Hernia.—At least as far back as the time of Celsus the *open operation* was done for the radical cure of hernia. This method was finally dropped and probably rarely performed during a period of about five hundred years, when it was revived in 1876 by Czerny. The principles upon which the modern operation is founded are the following:

1. Extirpation or obliteration of the hernial sac on a level with the general peritoneal sac.

2. Suture of the tissues of the canal in order to restore the parts as nearly as possible to the normal condition, or to diminish the size of the canal as far as possible, consistent with the safety of the cord.

3. The use of sutures which will be absorbed after a reasonable length of time and not remain to act as foreign bodies.

4. The maintenance of complete asepsis.

Unquestionably the best operation for the radical cure of inguinal hernia is that of Edward Bassini, first performed by him in 1884 and

published in 1889 in von Langenbeck's Archives, vol. xl., No. 2, when he reported two hundred and sixty-two cases operated on according to his method. About the same time, in June, 1889, Dr. Henry O. Marcy, of Boston, read an article on the "Cure of Hernia," at the meeting of the American Medical Association, at Newport, in which he described an operation performed by him the principles of which were almost identical with those of Bassini. Marcy tied or sewed across the hernial sac, cut it off, united the structures beneath the cord with his "shoemaker's stitch," restored the cord to its normal position, and then united the tissues over it, using kangaroo tendon as the suture material.

Bassini's Method.—1. Make an incision from a point about one inch within and about the same distance below the anterior superior spine of the ilium, over the inguinal canal to the external abdominal ring, dividing the skin and fascia and exposing the aponeurosis of the external oblique muscle. 2. Insert a grooved director through the external ring into the inguinal canal and split the aponeurosis, exposing the inguinal canal throughout its extent. 3. Strip back the edges of the aponeurosis from the underlying tissues, exposing the conjoined tendon on the inner side and Poupart's ligament on the outer side, which is continuous with the aponeurosis. 4. Open the sac of the hernia, separate it from the cord by blunt dissection well up within the internal ring, twist it, transfix and tie it, or sew it across, and cut it off. (In a congenital hernia the sac must be divided above the testicle and the upper portion of the sac treated by the method just stated.) 5. Lift the cord from its position and hold by a hook or loop of thread while the conjoined tendon (and rectus) are sutured to the shelving portion of Poupart's ligament from below upward, narrowing the internal ring to a degree just sufficient to permit the passage of the cord. The sutures should be about one-third of an inch apart. Bassini used silk first, and later catgut, but kangaroo tendon is the best suture. 6. Drop the cord into its normal position, and unite the aponeurosis of the external oblique muscle from above downward to the external ring by a continuous suture of kangaroo tendon. 7. Unite the fascia and skin by a single row of sutures. The external sutures may be silk or silkworm gut; or a subcuticular stitch of silver wire, silkworm gut, or kangaroo tendon may be used to unite the skin. The wound is closed without drainage, all hemorrhage having been arrested, a sterile dressing applied and kept in place by a spica bandage. The dressing need not be disturbed, unless there are special reasons for doing so, until the tenth or twelfth day, when the skin sutures are removed. The patient should be kept in bed three weeks and cautioned not to engage in

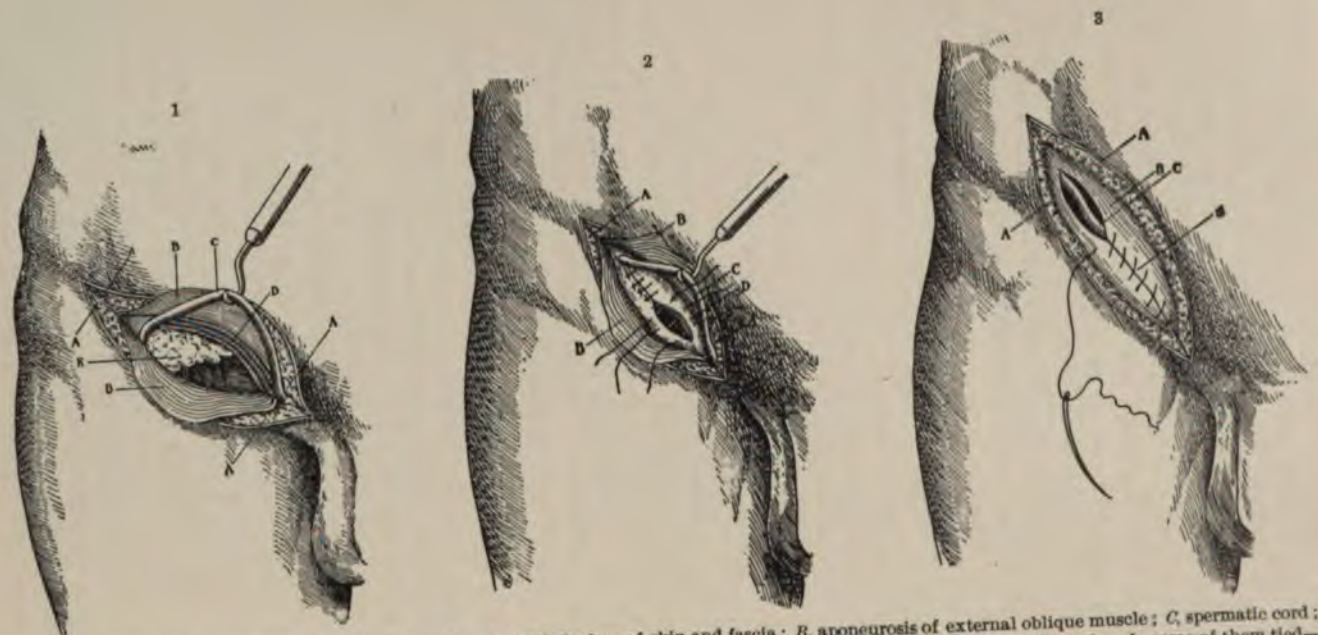

FIG. 263.—Bassini's operation for inguinal hernia: *A*, divided edges of skin and fascia; *B*, aponeurosis of external oblique muscle; *C*, spermatic cord; *D*, conjoined tendon; *K*, properitoneal fat at internal ring. 1, cord raised preparatory to introducing sutures; 2, sutures introduced—some of them tied—uniting the conjoined tendon to the shelving portion of Poupart's ligament; 3, aponeurosis of external oblique being united over the cord. (International Clinics.)

any laborious occupation for six months. A truss should not be worn after the operation. In a personal communication to the author, in 1895, Professor Bassini stated that he had operated seven hundred and ten times, with only one death and, so far as he had been able to ascertain, only nine relapses.

Kocher's Method.—Divide the skin and fascia as in Bassini's operation, but do not split the aponeurosis of the external oblique. Separate the sac from the cord by blunt dissection up to the internal ring. Insert a pair of long hæmostats through a small opening made through the external oblique muscle about one inch above the internal ring, pass them along the inguinal canal to the external ring, grasp the lower end of the hernial sac and withdraw it through the opening made for the hæmostats. Fold the sac lengthwise along the course of the inguinal canal external to the aponeurosis, and fix in this position by means of interrupted sutures which pass through the external and internal oblique muscles on either side, drawing a fold over the sac similar to the Lembert suture.

Macewen's Method.—The principal feature in this method is the treatment of the sac, through which a continuous suture is passed back and forth from its lower end to its neck. By drawing on the suture the sac is folded transversely on itself in the form of a pad, the end of the suture is carried through the abdominal wall about an inch above the internal ring, the folded sac is drawn into the abdomen, applied behind the internal ring, and held in place by fastening the suture. The conjoined tendon and Poupart's ligament are then united in front of the cord.

The Author's Method.—1. Make an incision over the inguinal canal from the internal ring to the centre of the symphysis pubis, exposing the aponeurosis of the external oblique. 2. Split the fibres of the aponeurosis, exposing the hernial sac and cord. 3. Separate the sac from the cord to within the internal ring, ligate or sew across and cut off. 4. Divide the conjoined tendon through its muscular part four or five centimetres (one and a half to two inches) above its insertion, including the internal pillar of the ring down to the transversalis fascia, avoiding the deep epigastric vessels. Separate by blunt dissection the conjoined tendon from the rectus and pyramidalis muscles down to the pubic bone, and place the cord in this position between the conjoined tendon and rectus. The cord still passes through an oblique canal, as the conjoined tendon overlaps the rectus and pyramidalis for about two and a half centimetres. Unite the divided ends of the conjoined tendon and internal pillar with mattress sutures, and accurately approximate them with continuous or interrupted sutures. 5. Close the old inguinal canal with interrupted

sutures, uniting Poupart's ligament to the conjoined tendon and rectus muscle, and in the outer part including the transversalis fascia. All stitches pass in front of the cord. 6. Unite the superficial structure with a continuous suture and the skin with a subcuticular or through-and-through sutures. Kangaroo tendon is the best suture material to be used throughout the operation. This operation has not been performed very many times, but the results, so far as ascertained, have been satisfactory.

Objections to this Operation.—Dividing the conjoined tendon is apt to leave a weak place in the abdominal wall in case of failure to get primary union; the operation requires more time and is a little more difficult to perform than that of Bassini.

Inguinal hernia in the *female* may be treated in the same manner as the corresponding condition in the male, Bassini's operation being the best, and the tissues may be closed tightly about the round ligament, or the round ligament may be included in the sutures.

Radical Operation for Femoral Hernia.—The danger of strangulation—this danger being at least five times as great as in inguinal hernia—and of pressure on the femoral and saphenous vessels requires the radical operation for *all cases of femoral hernia*, unless there are strong contraindications.

Bassini's Operation.—Make an incision over the saphenous opening parallel with Poupart's ligament, or slightly curved with the convexity below. Expose the sac, free it from the surrounding tissues, open it, reduce the contents, and transfix and ligate the sac as high up as possible. Cut off the lower part and push the stump above Poupart's ligament. Unite Poupart's ligament to the pectineal fascia by two or three interrupted sutures, being careful not to wound the femoral vein. Then unite the falciform process of the fascia lata to the pectineus fascia and muscle, leaving just room enough for the saphenous vein at the outer angle. It is best to introduce all the sutures before tying any.

Radical Operation for Umbilical Hernia.—The important points in operating on umbilical or ventral hernia are to close the peritoneum carefully after removing the sac and to unite the edges of the recti muscles direct.

Operation.—Make an elliptical incision, including the navel and the redundant portion of the skin, dividing the fascia and fat until the sac is exposed, freed from its attachments, opened, and the contents reduced. Sew the sac across with kangaroo tendon, or, if small, ligate with the same material and push within the abdominal walls. Split the sheath of the rectus on each side so as to expose the edges of the muscles. Unite the posterior layers of the sheath by

one row of sutures, the edges of the recti muscles by another, and the anterior layer of the sheath and skin by a third row of sutures, and close without drainage.

Accidents in Hernia Operations.—The *urinary bladder* has been opened or included in the ligature with the hernial sac and cut off in quite a number of cases in operating for inguinal hernia; the *vas deferens* has suffered; the *contents* of the *sac* have been injured by introducing the sutures without first opening and examining its contents, or have been torn in attempts to break up adhesions.

Results of Operation for Radical Cure.—The mortality of ten thousand cases of inguinal hernia operated on from 1886 to 1897, exclusive of strangulated hernia, was nine-tenths of one per cent., and it is estimated that 95 per cent. are permanently cured (Bull & Coley).

Treatment of Strangulated Hernia.—The writer once removed twenty-eight inches of gangrenous bowel in a case in which strangulation had existed just four hours. A little more than ten feet of intestine have been successfully removed, and it seems, from experiments on dogs, that this—about one-third of the tract—is probably the limit of what can be removed without being followed by death from inanition. Taxis is contraindicated. It has been estimated that the mortality after an apparently *successful* reduction by taxis has been 5 per cent. in femoral and 8 per cent. in inguinal hernia. Herniotomy in such cases would no doubt have been followed by better results.

Herniotomy.—Make a long incision extending over the neck and body of the hernia. Divide the coverings carefully until the sac is exposed below the neck or the seat of constriction. The sac can be recognized usually by its thick, fibrous character and pale color in old hernias, or by its dark-blue color and translucence in recent hernias. The sac is caught up by two pairs of hæmostats and opened between them. This is usually followed by a gush of serum, clear, bloody, or dark-colored, sometimes offensive in odor. The constriction should then be divided by carrying the incision upward through the external or internal abdominal ring, or both in inguinal hernia; or it may be divided by cutting the tissues from without, taking care not to injure the bowel. A probe-pointed knife may be used, or a grooved director may be inserted beneath the constriction, which may then be cut with a probe-pointed knife from within outward. As a rule, it is best to divide freely the tissues over the site of the constriction, in order to be able to control hemorrhage which may occur from the division of arteries near the ring. In femoral hernia the femoral canal and the lower part of Poupart's ligament should be divided. Having relieved the constriction, the contents of the sac

are examined, pulling down the coils of intestine to ascertain if volvulus exists. If the intestine is in good condition, as shown by a smooth, glistening peritoneal coat, which may be simply highly congested, or if dark-colored when first exposed, but after the relief of the constriction it becomes red and feels firm, elastic, and warm, it should be returned without delay, and if the patient's condition is good an operation for radical cure should be performed. In cases of doubt, as where the intestine is dark-colored and fails to turn red after the relief of the constriction, two courses are open to the surgeon: First, to leave the loop of intestine outside, with warm antiseptic dressings, for from twelve to twenty-four hours, when its condition can be positively determined; second, to resect the suspected portions at once and make an end-to-end anastomosis. The latter is preferable. If the intestine is already gangrenous, as shown by its black or gray color, dry, leathery, and sometimes cold sensation, resect at once and make an end-to-end anastomosis, either by circular enterorrhaphy or with Murphy's button. The latter is preferred when haste is necessary. When the patient's condition will not permit a continuance of the operation, an incision should be made in the gangrenous bowel, which is left in place for the formation of an artificial anus. If the sac contain gangrenous or doubtful omentum, ligate it in sections, if large, and remove the gangrenous portion.

Mortality from Operations for Strangulated Hernia.—The mortality at Johns Hopkins Hospital in cases of strangulated hernia operated from 1889 to 1899 was as follows: When the contents of the sac were in good condition, 8 per cent.; when the contents were gangrenous or there was general peritonitis, the mortality was 95 per cent.

The mortality at the Emergency Hospital, Washington, D. C., from 1897 to 1901—five years—was 12 per cent. when the contents were not gangrenous; and in gangrenous cases, nothing—all having been treated by resection.

In a study of three hundred and fifty-four operations for gangrenous hernia by Charles Langdon Gibson the average mortality was 34 per cent.; two hundred and twenty-six cases treated by resection, with immediate reunion of the intestine, gave a mortality of only 26 per cent.; while resection with artificial anus, or the formation of artificial anus without resection, which was done in one hundred and one cases, gave a mortality of about 52 per cent.

CHAPTER IX.

SURGERY OF THE GENITO-URINARY ORGANS.

INJURIES AND DISEASES OF THE KIDNEY.

CONGENITAL MALFORMATIONS.—The kidneys may be abnormal as to *shape*, *number*, and *situation*. One kidney may be absent; or the two may be connected at the upper or lower extremities by a bridge of tissue forming the *horseshoe* kidney; or they may be so completely united as to form only one organ—the *single-fused kidney*; or there

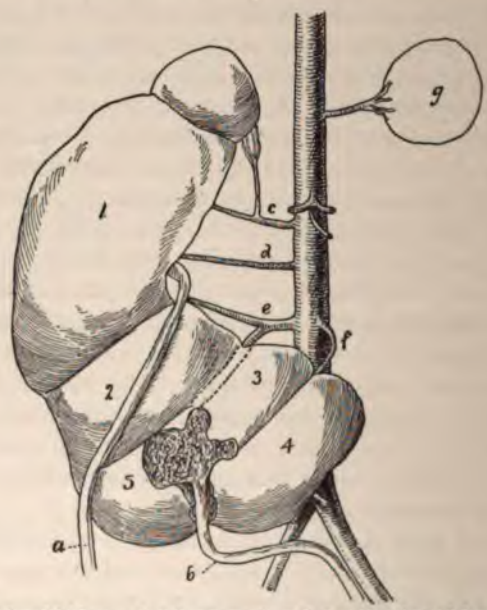

FIG. 264.—Single-fused kidney. (Author's case.)—1, 2, 3 4, 5 indicate lobes of the kidney. *a*, right ureter, from the pelvis of the vertical portion; *b*, left ureter, from the pelvis of the lower portion of the kidney; *c d, e, f*, arteries to the kidney and right suprarenal capsule; *g*, left suprarenal capsule with its artery.

may be three kidneys. The ureters are sometimes irregular There may be two ureters extending from one kidney to the bladder, or as many as a dozen from the kidney uniting with one another so as to form only one by the time it reaches the bladder. Finding the mouths of two ureters in the bladder is not proof of the existence of two kidneys, as they may both drain the same organ. The kidneys

may be located in the pelvis or at various levels along the lumbar spine. The kidney may be covered by peritoneum, and provided with a long process of this membrane, called a mesonephron, which permits it to float in the abdominal cavity—the true *floating kidney*. Cystic disease of the kidney is sometimes congenital.

MOVABLE KIDNEY. — A *movable kidney* is one which has an abnormal range of motion behind the peritoneum, and is different from *floating kidney*, which is a congenital condition. This affection is most frequently seen on the right side in thin persons, especially women with relaxed abdominal walls. Other causes are pressure from the liver or tumors, tight lacing, enteroptosis, and traumatism.

Symptoms.—Dragging pain in the back or side, worse in the erect position, often associated with digestive disturbances, enteroptosis, neurasthenia, and mental despondency. Exacerbations of pain may occur from twisting of the ureter, with swelling and tenderness of the kidney and diminished quantity of urine. Bimanual palpation reveals a movable tumor, which may be pushed into place, but readily returns.

Treatment.—A pad and bandage may be used to hold the kidney in position, or the patient may be kept in bed for several months. If this fail to give relief or if the symptoms are severe, *nephropexy* should be performed.

Nephropexy. — Place the patient in the lateral position, with a sand-bag or hard pillow under one side, in order to make the region of the kidney to be operated on prominent and increase the space between the ribs and the crest of the ilium. Expose the kidney by a vertical incision from the last rib to the crest of the ilium, two and one-half or three inches from the median line, dividing muscles, fascia, and the fat surrounding the kidney. Strip back the fat until the kidney is exposed, and have it held in place by an assistant making pressure through the anterior abdominal walls. Make a longitudinal incision two or two and one-half inches long through the fibrous capsule of the kidney, strip it back for a quarter of an inch on each side, and unite it to the lumber fascia with catgut or kangaroo tendon sutures. Stop all hemorrhage, close the incision without drainage, apply a pad over the anterior abdominal wall to hold the kidney in place, and keep the patient in bed at least three weeks.

The mortality from nephropexy is less than 2 per cent., with about 65 per cent. of permanent cures, 10 per cent. with improvement, and about 22 per cent. of relapses (Fenger).

WOUNDS OF THE KIDNEY result from blows, falls, crushing violence, gunshot, stab wounds, etc.

Symptoms.—There is usually more or less *shock*, sometimes *nausea* and *vomiting*. The *pain* is variable. In severe injuries the shock may be profound, with symptoms of hemorrhage. Blood may escape externally, if the wound be an open one; into the peritoneal cavity; behind the peritoneum; or into the pelvis of the kidney. *Hæmaturia* is an almost constant symptom in contusions and crushes of the kidney, occurring in 90 per cent. of cases (Fenger). Sometimes there are attacks resembling *renal colic*, from obstruction of the ureter with blood-clots. A *tumor*, tense or fluctuating, may be felt in the lumbar region. If infection take place, *chills* occur with rise of temperature and possibly pyuria.

Treatment.—Quiet and stimulants for shock. In open wounds disinfect the surface and dress antiseptically. If hemorrhage is severe and cannot be stopped by packing, enlarge the wound, expose, and suture the kidney. In *closed* injuries with serious hemorrhage, as indicated by a rapid pulse, restlessness, the presence of a tumor in the region of the kidney, with or without hæmaturia, expose the kidney by a lumbar or abdominal incision and arrest the bleeding by suture, or if the organ be badly disorganized, remove it.

HYDRONEPHROSIS is an accumulation of urine in the pelvis and calices of the kidney, causing dilatation of these parts.

Causes.—*Congenital hydronephrosis* constitutes one-third of the cases. It is due to twists or kinks of the ureter, or stenosis of some part of the urinary channel, and may be unilateral or bilateral. *Acquired hydronephrosis* is caused by the pressure on the ureters of tumors, malignant or benign; inflammations in the pelvis; obstruction by calculus (40 per cent. of cases); stricture due to inflammation or injury; and twists or kinks caused by movable or floating kidney (intermittent hydronephrosis).

Pathology.—The gradual pressure of the retained urine causes dilatation of the pelvis and calices with atrophy of the papillæ and pyramids, and later on of the cortical substance, until finally the kidney is converted into a large multilocular sac, the partitions corresponding to the calices and pyramids. The urine may change into an albuminous fluid of low specific gravity, containing no urea or uric acid.

Symptoms.—*Pain* is absent or slight, except in *intermittent hydronephrosis*, when it is often very severe. There is sometimes a history of attacks of *renal colic*, of the existence of tumors, or of *inflammatory affections* in the pelvis. Often there is no evidence of kidney trouble until a swelling appears in the loin or abdomen. There may be *frequent micturition* and diminution of the quantity of urine, almost amounting to anuria, which may be followed by the discharge of an abnormally large quantity. The presence of a *tumor* in the region of

the kidney may be determined. The tumor is usually fluctuating and may vary in size, sometimes disappearing coincident with a copious discharge of urine. A cystoscopic examination may show obstruction of one ureter, and by catheterizing this ureter the obstruction may be overcome and a large quantity of fluid withdrawn. Fever is rarely present.

Treatment.—If due to a kink or twist of the ureter from a movable or floating kidney, do a nephropexy. If due to stone in the ureter, remove it by incision; if due to a valvular obstruction, cure it by a plastic operation; if due to stricture, dilate it by the passage of catheters or sounds. If these measures fail, aspiration may be tried. In cases of hydronephrosis in which the kidney has been converted into a fibrous sac, perform nephrectomy.

SUPPURATIVE INFLAMMATION OF THE KIDNEY,—PYELITIS, PYELONEPHRITIS, AND PYONEPHROSIS.—In many cases these names indicate different stages of the same process.

Pyelitis denotes inflammation of the pelvis of the kidney. If the inflammation extends to the substance of the kidney, as it frequently does, with the formation of abscesses, it is called *pyelonephritis* or *surgical kidney*, as it sometimes develops after surgical operations on the bladder, urethra, or prostate gland. If the kidney becomes converted into a sac containing pus, the parenchyma having been destroyed, it is called *pyonephrosis.* The inflammatory process usually extends to the ureter, giving rise to *ureteritis.*

Causes.—The *exciting cause* is some pyogenic organism, especially the staphylococcus, colon bacillus, streptococcus, tubercle bacillus, occasionally the pneumococcus, typhoid bacillus, or gonococcus. *Predisposing causes* are those that produce hydronephrosis. The microbes may gain entrance through the circulation, by the use of an *infected catheter*, or as the result of inflammation. especially *gonorrhœa. Turpentine, cantharides*, and other chemical substances may produce a mild pyelitis independent of the action of micro-organisms.

Pathology.—In *pyelitis* the mucous membrane is red, swollen, with hemorrhagic points and deposits of fibrinous or calcareous material. If the inflammation extends further, producing a *pyelonephritis*, abscesses are formed in the parenchyma of the organ, which may or may not communicate with the pelvis. The inflammation may begin as a nephritis from metastasis, when both kidneys are usually affected, with numerous small abscesses situated in the parenchyma. As the process continues the parenchyma is destroyed, and the entire kidney is converted into a fibrous sac containing pus—*pyonephrosis.* Pyonephrosis may follow *pyelitis*, or it may result directly from infection of a *hydronephrosis.*

Symptoms.—In *acute* inflammation of the kidney the following symptoms are present: *Frequent micturition*, often a *chill* or *rigor* followed by *fever*, *pain*, or *uneasiness* in the back, sometimes *tenderness* over the kidney, and uræmic symptoms,—headache, vomiting, or coma. Examination of the urine shows an acid reaction; casts are usually absent, but pus and blood in variable amounts are generally found.

In *surgical kidney* the symptoms often come on insidiously after an operation. There may be no chill, and the temperature may be not at all, or very slightly, elevated; but the pulse is rapid and the patient apathetic. The apathy often deepens into coma, with a fatal termination.

In *chronic cases* there is seldom a chill, and the elevation of temperature may not be marked.

In *pyonephrosis* communication with the bladder is usually cut off and a tumor develops in the loin. The use of the cystoscope, or of Harris's segregator, is a valuable aid in making the diagnosis.

Treatment.—In *pyelitis*, or the early stages of inflammation, put the patient to bed, promote diuresis, and dilute the urine by giving large quantities of water or milk. Acetate of potassium or biborate of sodium may be given in doses of fifteen grains every two or three hours. Any obstruction should be relieved. Casper and others have treated pyelitis by catheterizing the ureters and washing out the pelvis of the kidney. Abscess of the kidney, pyonephrosis, and chronic pyelitis should be treated by opening and draining the kidney through the lumbar region, or, if the kidney substance is destroyed, by nephrectomy.

PERINEPHRITIS, or *perinephric abscess*, is an inflammation of the connective tissue surrounding the kidney.

The *causes* are wounds or contusions and extension of inflammation from the kidney itself or from adjacent organs, as from the appendix.

The *symptoms* indicate an inflammatory process in the region of the kidney, without definite changes in the urine, unless the process extends to the interior of the kidney. If suppuration occur with the formation of a perinephric abscess, there are chills, fever, and sweats; a tumor, tense or fluctuating; pain and tenderness in the loin. The course of the disease is often chronic. The abscess may open into the pelvis of the kidney, or dissect up the tissues and point externally, or open into one of the hollow viscera.

Treatment.—Open and drain the abscess by an oblique incision between the last rib and the crest of the ilium.

TUBERCULOSIS OF THE KIDNEY is usually unilateral, more common on the right side and in young adult males. It may be *primary*,

from the deposit in the kidney of tubercle bacilli which are floating in the blood; or *secondary* to deposits in the testis, bladder, or prostate, or as part of a general miliary tuberculosis affecting both kidneys, and is then not amenable to surgical treatment. Disease of one kidney soon extends to the bladder, and usually to the other kidney.

The *diagnosis* is made by the frequent micturition day and night, hæmaturia which is often excessive, the presence of pus and small particles of caseous matter in the urine, and, above all, by finding tubercle bacilli. The kidney may be felt enlarged, and the cystoscope may show tuberculous deposits about the mouth of the ureter.

The *prognosis* is always serious, and is very unfavorable when both kidneys are affected.

Treatment.—In *primary* tuberculosis in which the disease is limited to one kidney, perform nephrectomy. If the ureter is involved, it should be excised with the kidney. The cures resulting from *nephrotomy* were less than 2 per cent., while primary *nephrectomy* resulted in 40 per cent. of cures (Fenger). In addition to surgical treatment the patient should be placed in the most favorable circumstances for the arrest of the disease, especially as to climate and general hygienic surroundings.

TUMORS OF THE KIDNEY.—Tumors of the kidney may be benign or malignant. Among the benign tumors are fibroma, lipoma, adenoma, angioma, myoma, and cysts—congenital or hydatid. The malignant tumors are sarcoma and carcinoma. *Congenital cysts* often affect both kidneys. They are generally multiple and of variable size, grow slowly, and may not give rise to any symptoms until the patient reaches adult life, when a tumor may be detected on one or both sides in the place of the kidney. If the kidney tissue has been extensively destroyed, symptoms of uræmia may supervene.

The *treatment* consists in exposing the kidney, opening the cysts, and draining them. If the condition is bilateral, both kidneys should not be operated on at the same time.

Sarcoma occurs most frequently in children during the first four years of life, and is sometimes congenital; while, on the other hand, *carcinoma* usually occurs in adults who have reached the cancerous age.

Symptoms.—The symptoms of carcinoma and sarcoma may be considered together. There are often no symptoms until the tumor has reached considerable size. Pain is variable. Hæmaturia is an important symptom. Sometimes fragments of the tumor are discharged with the urine, giving rise to renal colic. An examination of these fragments may reveal the histology of cancer or of sarcoma. In

most cases a tumor can be felt in the lumbar region, and later on emaciation and cachexia arise.

The treatment is early and complete removal.

RENAL CALCULUS.—*Renal calculus*, *nephrolithiasis*, or *stone in the kidney* occurs with about equal frequency in both kidneys, in both sexes, and at all ages. It is found in the pelvis of the kidney, in the calyces, and in the parenchyma. Calculi vary in number from one to one hundred or more, and in weight from a few grains to two or more ounces. Not infrequently stone is found in both kidneys at the same time.

Causes.—Over-saturation of the urine with the crystaline salts, especially uric acid,—as a result of high living or of improper food,—lack of exercise, excess of nitrogenous and saccharine foods, malt liquors, excessive sweating, ingestion of too little water, and a gouty diathesis, acquired or inherited. The crystalline particles are held together by a colloid material, furnished by mucus or blood, which is often present as a result of irritation caused by the highly acid urine or by infection. Stone may also form around a nucleus composed of blood-clot or other foreign body, or around the dead cells from a catarrhal inflammation of the mucous membrane. Stone is composed most frequently of uric acid, next of calcium oxalate, in either case the urine being acid. More rarely it is composed of carbonate or phosphate of calcium—these salts precipitating when the urine is alkaline.

Symptoms.—A stone may exist in the kidney for an indefinite time without symptoms, provided it does not cause obstruction or infection (Fenger). Usually there is pain or uneasiness in the lumbar region, aggravated by movement, the pain sometimes extending down the cord to the testicle or thigh. It may cause the patient to lean towards that side and produce a lumbar scoliosis. Bimanual palpation may make out an enlarged and tender kidney and, rarely, grating of the stones may be heard or felt. There is often frequent urination during the day, the urine containing at times albumin, blood, or pus. Obstruction of the ureter may lead to suppression of urine or to pyelitis and pyonephrosis.

Renal Colic.—When the calculus becomes engaged in the ureter, in its passage towards the bladder, it is indicated by: Excruciating *pain*, in paroxysms, extending along the course of the ureter, down the inner side of the thigh, and in the scrotum; *frequent micturition*, the urine being faintly bloody; *nausea*, *vomiting*, and *profuse perspiration*. The attack lasts for from three or four hours to a week or longer, and ceases suddenly when the stone reaches the bladder. The calculus does not always complete its passage through the ureter; it

may fall back into the pelvis of the kidney, or it may become impacted at any point in the ureter. *Impaction* is denoted by the gradual disappearance of the *acute* paroxysms of pain, and in its place there is more a feeling of soreness or tenderness over the point of impaction. Blood and pus may be found in the urine, or chills, anuria, hydronephrosis, and pyonephrosis may result. Impaction may terminate in ulceration of the ureter, the escape of the stone into the connective tissue, and the formation of a lumbar or pelvic abscess.

Diagnosis.—Stone in the kidney or ureter must be differentiated from *tuberculosis, tumors, biliary colic, appendicitis,* and *intestinal colic.* In many cases a positive diagnosis can be made by the Roentgen ray or cystoscope.

Treatment.—Medicinal treatment may be prophylactic. Patients with acid urine should be given citrate of potassium, sodium bicarbonate, lithium carbonate, or piperazine, with large quantities of water. With *alkaline* urine and phosphatic deposits boric acid, or salol, five grains three or four times daily may be given. In *renal colic* relieve the pain by the use of morphine or chloroform, and assist the calculus on its way by warm baths and the copious ingestion of water. If impaction take place and is not relieved in three or four days, *ureterotomy* must be performed as described under surgery of the ureter.

Stone in the kidney should be removed by *nephrotomy* as soon as possible. If the signs and symptoms strongly indicate stone, expose the kidney and examine it with the touch, by passing a long needle into the tissue in various directions, or if necessary by nephrotomy.

OPERATIONS ON THE KIDNEY.

NEPHROTOMY AND NEPHROLITHOTOMY.—Place the patient on the sound side with a hard pillow under the loin in order to make the opposite loin prominent and increase the space between the last rib and the crest of the ilium. The best incision—unless the kidney is very large or the patient fleshy—is the *vertical incision* made from the lower border of the last rib to the crest of the ilium, along the outer border of the erector spinæ muscle about two and a half or three inches from the spinous processes of the lumbar vertebræ. The skin, fascia, muscles, and fat are divided and the kidney drawn into the wound, where it may be held and examined by palpation or by inserting a long needle through the kidney tissue towards the pelvis. If necessary make an incision large enough to admit the finger through the convex border of the kidney into the pelvis. If an abscess exist evacuate the pus, insert a rubber drainage-tube, and pack around with iodoform gauze. If a stone is found and removed, if there is no evidence of infection the wound in the kidney may be

completely closed and the external wound partly closed, leaving space for drainage.

The *oblique incision* is made about half an inch below the last rib from the outer border of the erector spinæ muscle, obliquely downward and forward towards the iliac crest for from three to five inches. Skin, fascia, part of the external and internal oblique and the latissimus dorsi muscles are divided, exposing the lumbar fascia, on incising which the perirenal fat is exposed. The peritoneum is stripped forward if necessary. The subsequent steps of the operation are the same as those given in the method by the vertical incision.

NEPHRECTOMY.—Nephrectomy should never be performed until the presence of a second kidney has been proved.

If the kidney is small, the *vertical* incision as described in nephrotomy may be used, but if much enlarged or it is necessary to remove the ureter, it is better to make the oblique incision, as the wound can be enlarged by extending it forward or backward. Separate the kidney from its attachments and if possible deliver it through the wound, clamp the pedicle with strong forceps, cut the kidney off, and ligate the vessels of the pedicle singly before removing the forceps. If the ureter is healthy, ligate and leave it; otherwise remove it as low down as possible by extending the incision forward and downward, keeping behind the peritoneum; or stitch it to the edges of the wound in the lumbar region. It is best to provide drainage. If there is doubt as to the existence of another kidney, open the peritoneum, pass the hand in and make sure.

Abdominal nephrectomy, or the transperitoneal method, is objectionable on account of the greater danger from opening the peritoneal cavity, while on the other hand it affords a good opportunity for the examination of the other kidney and gives plenty of room for the removal of a large tumor. The operation is performed as follows: Place the patient in the dorsal position with a pillow under the loins. Make an incision through the rectus muscle from four to six inches in length, with its centre opposite the umbilicus. Press the intestines towards the median line and keep them out of the way by the use of long towels of gauze. Incise the peritoneum on the *outer* side of the ascending or descending colon, and push the peritoneum and colon towards the median line until the kidney is exposed. Ligate the pedicle and remove the kidney, as already described. Make an opening through the loin at the outer edge of the quadratus lumborum muscle for drainage, and close the peritoneum behind and the abdominal wound in front.

Muscle-Splitting Operation.—Make an incision through the skin and fascia from the outer edge of the quadratus lumborum to the edge of

the rectus, as in the oblique method, separate the fibres of the external and internal oblique and transversalis muscles without cutting across their fibres, and push the peritoneum forward until the kidney is exposed.

RENIPUNCTURE.—Renipuncture is an operation recommended by Reginald Harrison for the relief of high tension and congestion of the kidney, usually associated with albuminuria or suppression of urine. The kidney is exposed in the usual way and the capsule and cortex punctured in several places with the point of a knife, or small incisions may be made.

DECORTICATION OF THE KIDNEY.—Edebohls strips the fibrous capsules from the kidneys in chronic nephritis in order to increase the blood-supply to the kidneys. Recent experiments on dogs show that the blood-supply is not increased by this operation; so the good effects are probably due to relief of tension.

INJURIES AND DISEASES OF THE URETER.

CONGENITAL MALFORMATIONS. — The ureters are occasionally double or multiple on one or both sides, and may open irregularly into the bladder or into other organs.

LESIONS.—The ureter may be injured in operations on the pelvic organs, *fistula* may result from the impacted calculus and sloughing, or *stricture* may be caused by inflammation, tuberculosis, or gonorrhœa. Stricture has been treated by Casper, Pawlik, Kelly, and others by catheterizing the ureters.

OPERATIONS ON THE URETER.

URETEROLITHOTOMY is an operation for removing an impacted stone from the ureter by incision. The upper three-fourths of the ureter can be reached by an extraperitoneal incision made by prolonging the ordinary incision for lumbar nephrectomy downward and forward about one inch internal to the anterior superior spine of the ilium to near the middle of Poupart's ligament. The peritoneum is stripped up until the ureter is exposed closely attached to the peritoneum. The tube is opened by a longitudinal incision, the stone removed, and a probe passed into the ureter above and below to search for other stones. The opening may be closed by fine silk sutures, or the wound may be left to heal spontaneously. In any case drainage should be provided until healing is assured. If the stone is impacted in the lower fourth of the ureter, it may be reached by opening the peritoneal cavity and cutting through the peritoneum covering the ureter. After removing the stone the wound should be

carefully closed with fine silk sutures and re-enforced by a graft of omentum. If the stone is impacted near the bladder, in the female it may be removed through a vaginal incision without opening the bladder or peritoneum; or if it project into the bladder it may be removed by means of a suprapubic cystotomy.

Fistulæ, strictures, and valves of the ureter may be treated by URETEROPLASTY, corresponding to *pyloroplasty* (Fenger).

URETERO-URETEROSTOMY.—*Van Hook's Method.*—This is an *end-to-side* anastomosis in which the distal segment of the ureter is ligated near its free end and an incision made into its side twice as long as the diameter of the ureter. The end of the proximal segment is then split on one side for about a quarter of an inch. Pass from within outward through the wall of the split ureter two fine cambric needles about the eighth of an inch apart, each carrying one end of a single suture of fine silk or catgut. Carry the needles in a similar manner through the slit in the lower segment of the tube, bringing them through its walls side by side about half an inch below the slit by drawing on the ends of the suture. The upper end of the ureter is drawn firmly into the lower end and the suture is tied. The line of junction may be re-enforced with a row of fine sutures, or by grafting peritoneum around it. Sometimes it is necessary to reduce the size of the upper segment considerably before introducing it into the lower segment.

End-to-End Methods.—The ends of the ureter may be united by dilating the lower segment, invaginating the proximal segment, and securing it by sutures. Other methods are direct end-to-end union, without invagination, of the two segments which may be cut transversely or obliquely; but these methods are more likely to leak than those by invagination.

Implantation into the Bladder.—The proximal end of the ureter, if long enough, may be implanted directly into the bladder, the distal end being closed by a suture or ligature. Implantation may be made extra- or intraperitoneally. The former method may be done in the female through the vagina. For the intraperitoneal method it is necessary to do a laparotomy. A slit is made through the bladder walls, and the end of the ureter, provided with needles and sutures, is slit and invaginated after the method of Van Hook. After tying the sutures, the point of junction is strengthened by a row of sutures including the outer walls of the ureter and bladder, and may also be re-enforced by adding a layer of peritoneum.

The mortality in thirty-seven ureterocystostomies for injury, collected by Bovee, was a little over 2 per cent.; and in forty-two for fistula, 10 per cent.

Implantation into the Bowel.—The indications for implantation of the ureter into the bowel are the impossibility of making an anastomosis or a bladder implantation for the relief of exstrophy of the bladder and after removal of the bladder for malignant growth. One or both ureters may be implanted. The great danger is nephritis from infection of the kidney by the intestinal organisms.

Maydl's Method.—This operation was first done in 1894, and is probably the best of the methods of intestinal implantation. It consists in cutting out the portion of bladder containing the mouths of the ureters, being careful not to injure the vesical arteries, and not cutting nearer to the mouths of the ureters than a quarter of an inch. A longitudinal incision is made into the rectum or sigmoid flexure of the colon, into which the piece of bladder is transplanted and fixed by two rows of fine sutures.

Of thirty-three cases transplanted into the sigmoid flexure and three into the rectum, there were five deaths (Reuben Peterson).

MALFORMATIONS AND INJURIES OF THE BLADDER.

CONGENITAL MALFORMATIONS.—The bladder may be entirely absent, the ureters opening into the urethra, rectum, or vagina; it may communicate with the rectum, or there may be supernumerary bladders; but the most common congenital malformation is exstrophy.

EXSTROPHY OF THE BLADDER, or ECTOPIA VESICÆ, is an absence of the anterior wall of the bladder due to incomplete development of the anterior wall of the abdomen. It usually occurs in males, and is associated with epispadias, absence of union of the symphysis pubis, and other deformities, such as inguinal hernia and undescended testicle.

Treatment.—Some appliance for protecting the mucous membrane and catching the urine may be worn, or an attempt may be made to cure the condition by operation. The *radical* method includes the various operations. *Wood's method* consists in dissecting up a flap of skin from the abdominal wall above the opening large enough to more than cover the bladder. This flap is turned down, skin surface internal, and carefully united by its edges to the skin around the bladder. Two lateral flaps are then taken, one from either side with the base towards the scrotum, and slid towards the median line until they cover the raw surface of the first flap. Thus the skin surface of the first flap will be turned into the bladder while the skin surface on the other two flaps is turned outward. The defects left by removal of the flaps are closed as well as possible by means of sutures. Repeated operations are often necessary before getting a good result, and the production of a sphincter is impos-

sible. *Maydl's method* consists in excising the portion of bladder containing the mouths of the ureters, and transplanting it into the sigmoid flexure or rectum, as described in the operations on the ureter. The remainder of the bladder is dissected out, and the opening in the abdominal wall closed by sutures.

PATENT URACHUS, or UMBILICAL URINARY FISTULA, is a condition due to imperfect closure of the urachus, the remains of the allantois extending from the urinary bladder to the navel.

Treatment.—Remove any obstruction which may exist in the urethra and apply a compress over the opening in the umbilicus. If this fail to cure, perform laparotomy, divide the urachus near the bladder, and close the opening in the latter by two rows of sutures. The operation may be done extraperitoneally.

INJURIES OF THE BLADDER.—The bladder may be punctured by spiculæ of bone from fracture of the pelvis, or it may be *ruptured* as a result of blows, kicks, falls, or violent compression. Rupture of the bladder may be intraperitoneal or extraperitoneal, most frequently the former.

Symptoms.—Shock or collapse; inability to urinate, although the patient has a great desire to do so; the catheter draws only blood or a little bloody urine; water injected into the bladder fails to distend it, and little or none can be withdrawn with the catheter. Air may be used instead of water, and may produce tympanites of the abdomen, and, if the rupture be extraperitoneal, there may be emphysema of the connective tissue. If the opening is *extraperitoneal*, urine escapes into the connective tissue of the prevesical space, the perineum, scrotum, thighs, abdomen, and back, where it soon produces sloughing and septicæmia. Peritonitis may set in within a few hours, but if the urine is healthy it may not occur for two or three days.

Treatment.—Expose the bladder by a suprapubic incision below the peritoneum, and inject water through the urethra. If the opening cannot be found or the bladder fail to become distended, open the peritoneal cavity and seek the opening. Close the wound, when found, with a double row of sutures. After suturing the bladder, it is best to provide for the continuous discharge of urine by means of a catheter in the urethra or through a perineal opening. When there is extravasation, multiple free incisions must be made through the skin and cellular tissue in order to evacuate the urine and give free drainage.

The *mortality* from rupture of the bladder, even with operative interference, has been high—50 per cent. or more.

DISEASES OF THE BLADDER.

RETENTION AND INCONTINENCE OF URINE.—Retention of urine, or inability of the bladder to empty itself, may be caused by many conditions, which are classified, according to White, under two headings,—namely: Obstruction from the front and defective expulsive force.

Obstructive causes include: Stricture of the urethra; hypertrophy or disease of the prostate gland; impacted calculus, blood-clot, or foreign body; tumors of the urethra or bladder; congenital atresia of the urethra or preputial orifice; pressure by a gravid uterus or tumors; fecal impaction; and a string tied around the penis, as has been done by children or ignorant nurses.

The causes included under *defective expulsive force* are the following: Paralysis from disease or injury; atony; shock; reflex inhibition, as after surgical operations, especially for hemorrhoids or hernia; great muscular weakness, as in low fevers; and the effects of certain drugs, as opium, belladonna, or cantharides.

Symptoms.—Usually the history of the case is sufficient. When acute, there is *intense desire to urinate*, with great *tenesmus*. When chronic, the symptoms may not be properly interpreted; tenesmus and the desire to urinate may not be present, but, on the contrary, there may be a dribbling (incontinence of retention) which may deceive both patient and surgeon. The *diagnosis* may be made by the presence of a hypogastric tumor, and confirmed by the passage of a catheter when that is possible.

Prognosis.—In *acute* cases, if unrelieved, suppression of urine may take place, with chills, fever, delirium, and death from toxæmia. In *chronic* cases the ureters become dilated, the kidney structure destroyed by pressure or suppurative inflammation, and the end is the same, only it comes on more slowly.

Treatment.—The kind of treatment will depend on the urgency of the symptoms and the cause of the retention. Sometimes a hot bath will relieve the difficulty, especially in children when the retention is due to spasmodic contraction of the urethra. When this fails, use the catheter. When the catheter cannot be used and the conditions are not favorable for a radical operation, aspirate the bladder, inserting the needle in the median line just above the pubes. After the needle is withdrawn, close the small wound with collodion. When the incontinence is caused by stricture of the deep urethra, perineal section may be done, thus relieving the retention and removing the obstruction at the same time.

INCONTINENCE OF URINE, or ENURESIS, is the escape of urine

without the consciousness or volition of the patient. *Active incontinence* is found in young children, especially boys, the causes being increased excitability of the urinary apparatus from phimosis, stone, ascarides, or polypi in the rectum, or a highly-concentrated urine. *Treatment.*—All sources of irritation should be relieved. Make the patient sleep lying on the side in a moderately cool room, and give a full dose of belladonna at bedtime. *Passive incontinence* is present when the neck of the bladder is unduly relaxed, as in paralysis of the sphincter vesicæ from shock, injury to the cord, or from mechanical distention by a tumor or calculus. *False incontinence*, retention with overflow or retention with incontinence, is due to temporary paralysis of the sphincter vesicæ from over-distention, the sphincter relaxing sufficiently to permit the escape of a little water; but the detrusor muscles are not capable of emptying the bladder, so that it remains full in spite of the dribbling. The treatment must be directed to the cause of the trouble.

ATONY OF THE BLADDER is a *lack of tone*, and is characterized by loss of muscular power, so that the urine can no longer be completely expelled. There are two varieties: *Physiological* atony occurs in most men after middle age; *pathological*, in which the bladder becomes dilated, with thin walls which have undergone a fatty or fibroid change, or contracted, with thick walls, and in neither case can it expel all of its contents.

Causes.—Advancing age; over-distention from any cause, such as neglect of the natural desire to urinate; as a sequel of true paralysis; stricture of the urethra; vesical tumors; or prostatic enlargement.

The *diagnosis* is made by finding urine in the bladder with the catheter after the patient has expelled all that he can—"residual urine."

Treatment.—In addition to treatment for the removal of the *cause* of the condition a systematic use of the catheter is necessary. The patient should be taught to use the catheter himself and the importance of keeping it perfectly clean by sterilizing it by boiling just before it is used. If the residual urine amounts to four ounces the catheter should be used twice, if six ounces, three times, and if it amounts to eight ounces, four times, in every twenty-four hours (White). The bladder may be washed out with cold boric acid solution; permanganate of potassium, one-half per cent.; or nitrate of silver, one-tenth of one per cent. Other remedies—electricity, strychnine, ergot, cantharides, or tincture of chloride of iron—may be tried.

CYSTITIS.—Inflammation of the bladder is the result of infection and may be *acute* or *chronic*.

Pathology.—The *predisposing* causes are exposure to cold and wet; the use of certain drugs, as cantharides; traumatism from retention of urine; the presence of a stone; or the use of a catheter. The *exciting* cause is some pathogenic organism, as the staphylococcus and streptococcus, the bacillus coli communis, the bacillus tuberculosis, the bacillus typhosis, and the gonococcus. The mucous membrane becomes congested, thickened, and swollen, with epithelium detached in places. At times there is ulceration, sloughing and even gangrene of the bladder may occur. The inflammation may extend to the subjacent tissues and abscesses form beneath the mucous membrane. As the disease becomes *chronic*, there is an excessive production of tenacious mucus, and the urine becomes alkaline from conversion of urea into carbonate of ammonium. The bladder walls become thickened from hypertrophy of the mucous membrane and of the muscular tissue, and trabeculæ are developed which interlace in various directions, forming polygonal spaces, in which the walls may be thin and sacculated. The bladder is often ulcerated, or encrusted with phosphatic deposits, and it may be generally dilated or contracted.

Symptoms.—In *acute* cystitis there is frequent micturition with great *tenesmus* and the passage of a small quantity of urine which may be clear at first, but soon becomes cloudy from the presence of mucus, and may contain blood or pus. There are sometimes chills, fever, pain in the bladder, which may extend into the penis, thigh, or perineum. As the disease becomes *chronic*, the symptoms are not so urgent, but the urine is decidedly cloudy or milky in appearance, with alkaline reaction, a fetid or ammoniacal odor, and separates on standing into two parts—the clear water above and the thick whitish pus, mucus, and crystals below. Pyelitis or pyonephrosis is apt to supervene, and the patient may die from uræmia or septic poisoning. When caused by the *tubercle bacillus* the early symptoms are often indefinite—probably some vesical irritability with slight hæmaturia, and red patches or ulcers on the mucous membrane. The tubercle bacillus may be found in the urine.

Treatment.—In the *acute stage* give mild diluent diuretics, as acetate or citrate of potassium, fifteen grains in water every two hours, with a diet of milk and fruit; suppositories of opium and belladonna or cocaine; and irrigate with some mild fluid, as salt solution. *Chronic stage:* Draw the residual urine regularly and irrigate the bladder with mild antiseptics, as peroxide of hydrogen, from 25 per cent. to full strength; boric acid, 2 to 10 per cent.; nitrate of silver, one-half to 2 per cent.; permanganate of potassium, one-half to 3 per cent.; and corrosive sublimate, 1 to 15,000. By the

mouth certain remedies which have a specific action on the urine may be given, such as salol, urotropin, copaiba, cubebs, turpentine, buchu, uva ursi, etc. For *tuberculosis* of the *bladder* try daily injections of iodoform emulsion in olive oil after washing out the bladder (W. B. Clarke).

STONE IN THE BLADDER.—There are two principal *causes* in the formation of all cases of vesical calculus,—namely, (1) *conditions which favor excessive production and deposit of the solid constituents of the urine*, such as the want of balance between digestion and assimilation; excessive use of meat, fats, sugars, with insufficient exercise and oxidation; and certain constitutional diseases, as gout, rheumatism, and lithæmia; (2) *local diseases that favor the formation of mucus or pus which furnishes the colloid material* to hold the crystalline products together in building the stone, such as enlarged prostate, stricture of the urethra, atony of the bladder, or infection from any source. Stone occurs at all ages; it is rare in females; it is more common in limestone regions and in certain countries, as India.

Varieties and Chemical Composition.—By far the most common form of stone is the uric acid. This forms in *acid urine*, as do oxalate of lime, urates of sodium and potassium, and the rare forms—cystin, xanthine, and indigo. Those which form in *alkaline urine* are phosphate or carbonate of lime—usually in the kidney—and the ammoniomagnesium phosphate, or triple phosphates, in the bladder.

Every stone has a *nucleus* around which the successive layers are deposited, somewhat like the scales of an onion around its centre. The successive layers may be composed of the same material as the nucleus, but are often different; thus, a uric acid calculus may form in the kidney and pass into the bladder, where it becomes coated with phosphate or oxalate of lime. The most common nucleus is uric acid; others are urates or oxalate or carbonate of lime; mucus, pus, blood; ligatures, fragments of bone, bullets, pencils, penholders, shoestrings, crochet-needles, chewing-gum, ichthyol, hairpins, and fragments of catheters. In number they vary from one to a thousand or more, and in size from that of a birdshot or pea to the size of a hen's egg or larger, weighing a pound or more. The hardest stones are composed of calcium oxalate, are brown in color, and usually have rough surfaces—"mulberry calculi." The phosphatic stones are soft and grayish or white, while the uric acid stones are intermediate in hardness and reddish or brown in color.

Symptoms.—1. There is often a history of one or more attacks of renal colic. 2. Frequent urination, worse in the day than at night, and increased by motion, the desire being sudden and irresistible. 3. Pain—which is slight in some cases, in others severe, especially just after

urination, when the bladder walls come in contact with the rough surface of the stone. It is often felt at or near the end of the penis, sometimes in the perineum, rectum, thighs, in the ball of the foot, the great toe, or the other toes. 4. Sudden interruption of the stream while urinating, caused by the stone rolling into the neck of the bladder. The patient may assume some peculiar position in order to obviate the difficulty. 5. Hæmaturia and, sooner or later, cystitis.

The *diagnosis* can only be made positively by feeling the stone with a sound or searcher and hearing the click; by seeing it with the cystoscope or by means of the X-ray; or by digital exploration through an opening in the bladder. The stone may not be found because of small size and incomplete examination; it may be protected by a projecting portion of the prostate gland, covered with blood-clot or lymph, encysted or contained in a diverticulum, or it may be attached to the summit or anterior wall of the bladder by fibrinous adhesions.

Treatment.—The formation of stone in the bladder may possibly be prevented by proper treatment,—limiting the amount of meat, sugar, fats, and alcohol, increasing the amount of exercise, and drinking water freely. After the stone has formed, the only treatment is to remove it as soon as possible. Preliminary treatment is necessary before operating. Regulate the kidneys and bowels; keep the patient in bed two or three days before operation; if cystitis exists, irrigate the bladder with mild antiseptics, and give a laxative the day before the operation.

Litholapaxy.—In *litholapaxy*, or *Bigelow's operation*, the stone is crushed and evacuated at one operation. In suitable cases this is the ideal operation for the removal of vesical calculus, but to attain the highest degree of success it requires more skill and experience than the cutting operation.

Contraindications to litholapaxy are: Stricture of the urethra, which prevents the passage of proper instruments; disease of the bladder, which prevents it from holding five or six ounces of fluid; cases in which drainage by a cutting operation would be beneficial; and the presence of a stone more than two inches in diameter or too hard to be crushed.

Operation.—Prepare the patient by shaving and disinfecting the genital organs, anæsthetize him, or use cocaine, and place him in the lithotomy position, with a pillow under the hips. Wash out the bladder with a solution of salt or of boracic acid, and leave about six ounces of fluid in the bladder. Standing on the patient's right, introduce the lithotrite—Thompson's, Bigelow's, or Forbes's—until the beak of the instrument touches the posterior wall of the bladder.

Hold the instrument steadily in this position with the left hand, and with the right hand gently withdraw the male blade until it touches the neck of the bladder, slide it back towards the female blade, and often the stone will be found in its grasp. If not, turn the open instru-

FIG. 265.—Bigelow's lithotrite.

ment to the left and close the blades; then to the right and close the blades; or completely over, repeating the process. Having seized the stone, press it firmly to see if it will slip. Lock the instrument, withdraw to the centre of the bladder, see that no mucous membrane is caught, and crush the stone by gently turning the screw; catch

FIG. 266.—Bigelow's improved evacuating apparatus.

and crush the various fragments by the same process until no more fragments can be caught. Close and withdraw the lithotrite, insert an evacuating tube, attach the aspirator, and alternately compress and relax the bulb so that an ounce or two of fluid is forced into the bladder and withdrawn at each motion. The fragments are thus

drawn out and fall into the glass bulb attached to the lower part of the aspirator. This is kept up until fragments cease to be withdrawn, after which the patient is put to bed and treated according to symptoms. If retention occurs, the catheter must be used. The patient is usually well enough to get up in a week or ten days.

Accidents may be clogging of the lithotrite with débris so that the blades cannot be closed and withdrawn—such an accident may require a suprapubic or perineal cystotomy in order to free the blades; the evacuating tube may become blocked with the fragments, in which case make quick, forcible pressure of the bulb to dislodge them; the bladder wall may be sucked against the end of the tube, producing the "fish-bite" sensation, and indicating the need of more water; severe hemorrhage from the mucous membrane may require the injection of hot water; the wall of the bladder may be caught between the blades of the lithotrite and severely injured—but this accident is not likely to occur unless the bladder is fasciculated or otherwise diseased.

Perineal lithrotrity, or *Keith's operation*, is a Bigelow's operation performed through a median incision in the perineum. It is used in cases of very hard calculi, or when it is impossible to introduce a lithotrite through the anterior urethra.

Lithotomy may be *suprapubic* or *perineal*.

Suprapubic lithotomy is indicated when the stone is unusually large —over two inches in diameter—or is too hard to be crushed by the lithotrite. *Operation.*—After the usual preparation, anæsthetize and place the patient upon the table in the Trendelenberg position, and inject the bladder with six or eight ounces of warm salt solution. Make an incision about three inches long from the upper border of the pubes upward between the recti muscles. Divide the tissues, separating the recti muscles until the connective tissue and fat in front of the bladder are exposed. The peritoneum is usually not seen, but if it comes into the wound it should be pushed up out of the way. On separating the connective tissue and fat the bladder wall is exposed. Introduce a suture by means of a round curved needle on each side of the line of the proposed incision in order to have control of the bladder. Make an incision about one inch in length between the sutures. As the water gushes out introduce the finger, explore the bladder, extract the stone by means of forceps or curette, or if performed for other purposes, as the removal of tumors, proceed according to requirement. A drainage-tube is then inserted, the wound partially closed and allowed to heal by granulation, which usually takes place in six or eight weeks; or the wound may be entirely closed by sutures, especially if there is no cystitis

present. Two rows of sutures should be used, the second inverting the first, and neither passing through the mucous membrane. When the wound is closed, distention of the bladder must be prevented by

FIG. 267.—Side view of male pelvic viscera: *a*, ureter; *b*, vas deferens; *c*, peritoneum; *d*, symphysis pubis; *e*, rectum; *f*, bladder; *g*, visceral layer of pelvic fascia; *h*, urethra; *i*, vesicula seminalis; *j*, prostate gland. (After Gray.)

permanent catheterization through the urethra or by introducing a catheter through a perineal incision.

Perineal Lithotomy.—There are three methods of perineal lithotomy,—the *lateral*, the *bilateral*, and the *median*.

Lateral lithotomy is indicated in cases of *stricture* when it is desirable to divide the stricture by an external incision, and in *cystitis* when drainage of the bladder is essential.

Objections to the operation are: Difficulty in performing it; danger of hemorrhage from the artery or spongy tissue of the bulb, or the internal pudic artery; of cutting the duct of the vas deferens, wounding the rectum, lacerating the urethra, or even tearing it in two in children; or the attempt to get the finger or forceps into the bladder may fail.

Operation.—Place the patient in the lithotomy position, the buttocks projecting over the end of the table, with the legs flexed on the thighs and the thighs on the abdomen, in which position they are held by an assistant on either side. Introduce into the bladder a grooved staff and give it to one of the assistants, who holds it vertically with the concavity of the staff hooked up against the arch of the pubes. Make an incision from one and a quarter inches in front

of the edge of the anus downward and outward to a point about midway between the anus and the left ischial tuberosity. Divide the skin, fascia, transverse perineal muscle, nerves and vessels, external hemorrhoidal nerves and vessels, and part of the triangular ligament, and introduce the forefinger of the left hand into the wound and find the groove in the staff. Place the point of the knife in the groove and push it along, incising the membranous urethra and left side of the prostate gland, parallel with the external wound, until it enters the bladder, which is known by the escape of urine. Carry the left forefinger along the staff into the bladder, withdraw the staff, explore the bladder, and find the stone, introduce the forceps by the side of the finger, seize and withdraw the stone by a gentle motion. Search for and remove other stones if present, irrigate the bladder with warm salt solution, introduce a soft catheter through the wound, dress, and put the patient to bed. The catheter may be removed after two or three days, and in many cases it is not necessary to introduce it at all.

FIG. 268.—Incisions for lithotomy,—lateral, transverse, and median.

In the bilateral or transverse method a semilunar incision is made across the perineum, three-fourths of an inch in front of the anus, and the membranous urethra and prostate are incised on both sides by pushing a bisector into the bladder.

In median lithotomy the knife is introduced half an inch in front of the anus, with the cutting edge upward, and pushed carefully onward, guided by the finger in the rectum, to the apex of the prostate, into the groove of the staff. The incision is enlarged in front, taking care not to injure the bulb, and the apex of the prostate incised until the finger can be introduced into the bladder and the staff withdrawn.

TUMORS OF THE BLADDER.—The most common tumors of the bladder are papilloma and epithelioma. They occur most frequently in or near the trigone. Papilloma may be single or multiple, pedunculated or sessile.

Diagnosis.—Repeated hemorrhages occurring in young persons without apparent cause point to *papilloma*. Hemorrhages not very severe occurring in elderly persons, with considerable pain and other

evidence of cystitis, indicate *epithelioma*. Sometimes pieces of the tumor are passed with the urine, when a microscopic examination may reveal its character, or the tumor may be felt by bimanual palpation or by the introduction of a sound into the urethra, especially if the tumor has become encrusted with the urinary salts. In all cases a cystoscopic examination should be made.

Treatment.—When possible remove the growth by a suprapubic cystotomy. If a polypus, it may be twisted off; if a sessile growth, it may be curetted off or excised, and the opening in the mucous membrane closed by sutures. But little can be done for malignant growths unless they are situated so that resection of the bladder wall can be done. The bladder can be excised and the ureters transplanted.

THE CYSTOSCOPE.—The cystoscope is an instrument invented by Nitze for the purpose of seeing the interior of the bladder. Its essential parts are a straight tube, one end of which is bent at an obtuse angle, and a small incandescent electric light in the distal end connected by wires which run through the shaft of the instrument to the battery outside. At the angle is a glass prism which receives the rays of light from the bladder and reflects them through a system of lenses in the shaft until they are brought to a focus at the eye-piece.

Casper has invented an instrument called a *uretercystoscope*, which contains a groove through which a fine catheter is passed so that by looking through the instrument the catheter can be introduced into the mouth of the ureter, or even further on if desired, to the pelvis of the kidney. The instrument can be detached, and the catheter left in position to collect the urine from the kidney. There are several modifications of the cystoscope now in use, made in various countries.

In the female the bladder can be examined with the endoscope by dilating the urethra to a diameter of from twelve to fifteen millimetres, placing the patient in the lithotomy position with extreme elevation of the pelvis, so that the contents of the abdomen fall away; a short cylindrical endoscope or speculum is introduced into the urethra, the urine withdrawn by means of a suction bulb, when the interior of the bladder distended by air can be seen by the aid of a head mirror, the mouths of the ureters located, and if necessary catheterized.

HARRIS'S SEGREGATOR.—M. L. Harris, of Chicago, has invented quite an ingenious instrument for the purpose of collecting the urine separately from the two kidneys without the necessity of catheterizing the ureters. It consists of two catheters enclosed in a common sheath and connected with a flat lever which is inserted into the rectum in such a manner as to press the base of the bladder upward

and make a pouch on each side into which the ureters discharge separately and from which the urine can be drawn separately with the two catheters.

DISEASES OF THE PROSTATE GLAND.

INFLAMMATION of the prostate may be *acute* or *chronic*. The *causes* are: Injury, the occurrence of certain diseases, such as gout, typhoid fever, or influenza. The *acute* form is usually caused by the gonococcus as a result of extension of the disease from the urethra. The inflammation may be limited to the follicles, or it may extend to the parenchyma of the gland and result in chronic inflammation (prostatorrhœa), in hypertrophy, or in abscess. *Tuberculous* infection causes a chronic inflammation with the formation of cheesy deposits. Prostatic calculi sometimes form in the follicles. Tuberculosis of the prostate is often accompanied with, or preceded by, a corresponding disease of the seminal vesicles, epididymis, or bladder.

Symptoms. — *Acute prostatitis* is manifested by pain, fever, and frequent urination, the urine being often tinged with blood. Examination per rectum shows the gland to be swollen and tender. Retention of urine may occur, and the use of the catheter causes great pain. The formation of an *abscess* is usually shown by chills or chilly sensations and more pronounced constitutional symptoms. The abscess may open into the urethra, rectum, or through the perineum. *Chronic prostatitis* affecting the *follicles* is shown by a thin whitish discharge (gleet), frequent urination, a sense of weight in the perineum, diminished force in the stream of urine, and sometimes unusual sexual excitability. If the urine is passed into two glasses, only the first one will be found to contain shreds consisting of mucopus and prostatic epithelium. *Tuberculosis* of the *prostate* has the symptoms above described, and hæmaturia sometimes occurs. The seminal vesicles are often affected at the same time, and by rectal examination can be felt enlarged and hardened; but the *diagnosis* is made by finding tubercle bacilli in the urethral discharge or by the use of Koch's tuberculin.

Treatment.—In the *acute* form give a laxative and alkaline diuretics with hot baths, and the injection of warm water into the rectum and urethra. If the symptoms point to the formation of an *abscess*, make an incision through the perineum into the gland. *Chronic* prostatitis requires the local application of nitrate of silver, 1 to 5 per cent.; protargol; or ointment of iodoform or nitrate of silver, from 1 to 5 per cent., may be used. The systematic passage of large sounds often has a beneficial effect on the prostate. *Tuberculous prostatitis* should be treated by the removal of the diseased

portion of the gland along with the organs primarily affected, such as the epididymis or seminal vesicle. When this is not practicable, urethral injections of iodoform, once daily, are often beneficial. Prostatic calculi should be removed by a forceps or curette, through an endoscope when possible, or by a perineal incision into the urethra and prostate.

HYPERTROPHY OF THE PROSTATE.—Hypertrophy of the prostate gland is said to occur to a sufficient degree to cause trouble in 10 per cent. of all males over fifty-five years of age.

Etiology and Pathology.—Some authorities (as Lydston) attribute it to general atheroma of the arteries, or to local irritation or inflammation of a chronic character. The enlargement may be general in character, a true hyperplasia affecting the muscular, glandular, and connective tissues of the organ. The increase may be principally confined to the connective tissue. The enlargement may consist chiefly of an overgrowth of gland tissue (rare), or there may be local hypertrophies and the formation of tumors,—fibromyomata corresponding to fibroids of the uterus, of which the prostate gland is the homologue. The *size* of the gland or of the tumors varies from that of a pea to an orange. In *shape* the enlargement or new growth varies in the same way. Either lobe may be affected, or the enlargement may be general. There may be a general enlargement of the median portion, or it may take the form of a sessile or pedunculated tumor projecting into the urethra or neck of the bladder, or of a bar or collar projecting across the origin of the urethra. The bladder also undergoes changes, and is apt to become pouched from the growth of the prostate backward and upward, one pouch being in front of, and the other posterior to, the gland; or it may become sacculated and contracted, or dilated, with thin walls. In any case atony is apt to occur.

Symptoms.—Increased frequency of urination, more marked at night than in the day—probably from congestion of the neck of the bladder when the patient becomes warm in bed; *sudden retention* of urine after exposure to cold or wet, or excessive eating or drinking; dribbling after urination, and inability to empty the bladder completely on account of the obstacle furnished by the prostate and the retention of some of the urine,—"residual urine,"—ascertained by using the catheter after the patient has expelled all the urine he can. Cystitis occurs from infection of the "residual urine," causing it to become fetid and ammoniacal, while the patient suffers burning pain, tenesmus, and constant desire to urinate. Pyelonephritis and general sepsis are apt to follow, ending in uræmia and death.

Diagnosis.—The diagnosis is made by feeling the enlargement on

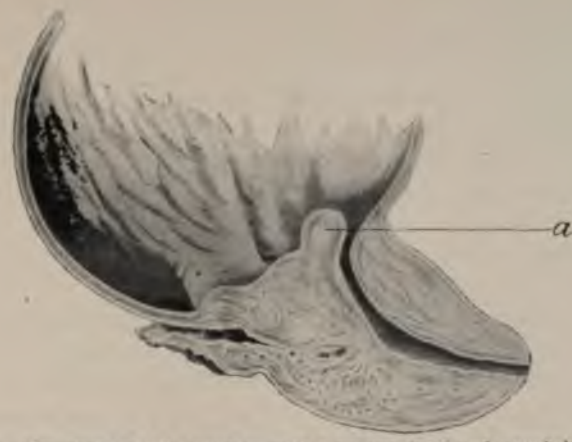

Fig. 269.—Hypertrophy of the prostate, with a pedunculated and rounded lobe (a).

Fig. 270.—Symmetrical hypertrophy of the prostate, with (a) the so-called "horse-collar" enlargement, completely encircling the urinary outlet. Such a case would probably require two good-sized incisions with the galvanocautery, one on each side of the median line, directed towards its centre. (International Clinics.)

digital examination through the rectum, by the marked depression of the handle which is necessary in order to make a sound or catheter enter the bladder, and by the existence of "residual urine." Sometimes the instrument cannot be made to enter the bladder without great force, on account of the point striking a median enlargement or a tumor or bar across the neck of the bladder. Carcinoma and tuberculosis must be excluded.

Treatment.—In mild cases, where operative measures are contraindicated, temperate habits, the avoidance of constipation and exposure to cold, and the intelligent use of the catheter will often prevent diseases of the bladder and kidneys and render the patient's existence comfortable. Urinary antiseptics may be given, as the oil of eucalyptus, salol, urotropin, and sour milk containing lactic acid (Lydston).

The use of a soft catheter should begin as soon as there is "residual urine." It should be used from once to four times in twenty-four hours, according to the amount of residual urine. A catheter coudé, or silver catheter with a long curve, may be required to surmount the obstruction. If cystitis occur, irrigate the bladder for from one to three times daily with warm solution of bichloride of mercury, 1 to 15,000, permanganate of potassium, 1 to 3000, or boric acid, 2 per cent. When the catheter cannot be used, or there is severe cystitis, but a radical operation is impracticable, *permanent drainage* of the bladder is indicated and can be obtained by a perineal cystotomy.

For the *radical* cure, one of the following operations may be performed: Gonangiectomy (excision of the vasa deferentia); castra-

FIG. 271.—The Bottini-Freudenberg incisor.

tion; the Bottini-Freudenberg operation; or prostatectomy. Castration, introduced in 1893 by J. W. White, is of doubtful value. The same may be said of gonangiectomy. The Bottini-Freudenberg operation, recently revived and improved, is at present quite popular. The instrument used resembles a lithotrite, the male blade consisting of a galvanocautery knife. The operation may be performed under cocaine. The instrument being introduced into the bladder,

the beak turned down and withdrawn until it rests against the obstruction, the electric current is turned on and the cautery knife withdrawn by means of a wheel in the handle, until it cuts through the obstruction. The blade is then pushed into place, the current turned off, and if necessary a groove is burned in a similar manner into the lateral lobes of the prostate, one on each side. This operation is especially suitable in those cases in which the obstruction consists of a bar or collar in the neck of the bladder. It may also be preferred as a milder operation than prostatectomy in very old patients with diseased bladder or kidneys. The objections to this operation are the uncertainty of operating in the dark, the danger of cicatricial contraction causing a return of the obstruction, and the fact that the obstruction is seldom completely removed.

Prostatectomy is performed by the *suprapubic* or *perineal* method, or by a combination of both.

The *suprapubic method* gives the best command of the field of operation and enables the surgeon to make a more thorough examination of the growth as it affects the bladder and urethra. The bladder is opened in the usual way, and held open by means of a ligature on each side of the opening. By palpation and inspection the condition of the prostate is ascertained. Pedunculated tumors are twisted off; sessile tumors are removed by incising the mucous membrane, introducing the finger, and enucleating the tumor. Collar-like projections or bars are excised. Hemorrhage is arrested by hot water or pressure. An opening may be made in the perineum for drainage and the suprapubic wound partially closed.

Perineal Prostatectomy.—Place the patient in the lithotomy position. Introduce a grooved staff, insert the left index-finger into the rectum, and feel the apex of the prostate gland and the staff. Enter a narrow-bladed, double-edged knife in the median line, half an inch in front of the anus, open the prostatic urethra, and incise the apex of the prostate gland. The growth may then be removed by means of forceps if pedunculated and projecting into the bladder; or the capsule of the gland may be incised and each lateral lobe enucleated by means of the finger. Perineal prostatectomy is also performed by means of a curved incision, with the convexity forward, made half an inch in front of the anus. The prostate may be pulled down by means of hooks and enucleated without opening the urethra.

The Combined Method.—In this method the prostate may be removed either through the suprapubic or perineal incision, while the fingers in the rectum or in the bladder push the gland into an accessible position.

THE URETHRA.

The meatus is the smallest part of the urethra; the bulbomembranous junction is the next in size; while the prostatic portion is the widest and most dilatable part. The fixed curve of the urethra extends from just in front of the triangular ligament to the neck of the bladder. It is represented by the curve of a circle three and a quarter inches in diameter, and corresponds in length with an arc of such a circle subtended by a chord two and three-quarters inches long, while a chord two and five-sixteenths inches long subtends the arc which should represent the curve of the sound or catheter (Van Buren and Keyes).

Size of the Urethra with Relation to the Circumference of the Penis.—A penis three inches in circumference at the middle should admit a sound of the size of twenty-six to twenty-eight millimetres; three and one-quarter inches in circumference, a sound twenty-eight to thirty millimetres; three and one-half inches in circumference, a sound thirty to thirty-two millimetres; three and three-quarters inches in circumference, a sound thirty-two to thirty-four millimetres; four inches in circumference, a sound thirty-four to thirty-six millimetres (J. William White).

Scales of Sounds and Catheters.—Three different scales for urethral instruments are in use, namely: The French, the American, and the English. 1. The French standard is one-third of a millimetre (one seventy-fifth of an inch) in diameter, and increases one-third of a millimetre in diameter for each size. The number of the instrument gives its diameter in thirds of a millimetre, and nearly corresponds with the circumference in millimetres; thus, No. 15 is five millimetres in diameter and about fifteen millimetres in circumference. 2. The American scale is based on a standard the fiftieth of an inch in diameter. 3. The English scale is arbitrary, but the English instrument corresponds in size with the American of about two numbers greater; thus, No. 8 English corresponds with No. 10 American. To convert the French into the American scale, subtract one-third; thus, No. 30 French equals No. 20 American. To convert the American into the French scale, add one-half; thus, No. 20 American equals No. 30 French, the corresponding English number being No. 18.

INJURIES OF THE URETHRA.

LACERATION and RUPTURE of the urethra may be caused in the *pendulous* portion by sexual intercourse or by "breaking" a chordee. In the *bulbous* portion of the urethra, where the rupture or laceration occurs most frequently, the cause is usually a blow, a kick, or falling

astride of some hard object, as the edge of a board or fence-rail—catching the urethra between the hard body and the arch or rami of the pubes. A common cause of laceration of the urethra is the careless use of sounds or catheters, making false passages, usually in the bulbous or membranous portion. The urethra may also be injured by fragments of bone in fractures of the pelvis. The injury varies from a slight tear to one in which the urethra may be torn entirely across.

Symptoms.—Pain, sometimes great shock; urination is difficult, impossible, or attended with hemorrhage; free bleeding from the meatus; swelling in the perineum or penis from effusion of blood, from extravasation of urine, or from both; and often it is impossible to pass a sound into the bladder.

Treatment.—If the hemorrhage is severe but the patient is still able to pass water, the bleeding may be arrested by pressure over the region of the injury, with or without the presence of a full-sized catheter in the urethra for counter-pressure. When urination and catheterism are impossible and the urethra is probably torn across, perineal section should be made at once, the ends of the urethra sought and united over a catheter which should be left in place. If the proximal end of the urethra cannot be found, it is justifiable to make a suprapubic opening and pass a sound from behind. If the ends of the urethra cannot be united, the wound in the perineum should be left open for drainage and a sound passed at regular intervals to prevent contraction.

DISEASES OF THE URETHRA.

There are two varieties of urethritis, namely: Gonorrhœa or specific urethritis, and simple or non-specific urethritis.

GONORRHŒA,—literally, a flow of semen,—CLAP, or SPECIFIC URETHRITIS is a disease peculiar to the human animal, caused by infection with the gonococcus, an obligate pyogenic parasite discovered by Neisser in 1879. It usually occurs as a diplococcus 1.25 micromillimetres in diameter. It can be cultivated on blood serum, stains with methyl blue, and is decolorized by Gram's method. The gonococcus is often aided by other pyogenic bacteria. It has a special affinity for mucous membrane covered with cylindrical epithelium, but it may also affect other mucous membranes, as those of the eye, nose, mouth, rectum, and synovial membranes. While the disease is usually contracted by the sexual act, it may be acquired in an innocent way by the use of towels, handkerchiefs, syringes, the fingers, etc.

Pathology.—On coming in contact with the mucous membrane of the urethra, the gonococci multiply rapidly and penetrate the epithe-

lium and subepithelial tissue, producing an acute inflammation, with heat, pain, redness, and swelling, and desquamation of the epithelium. This action may be limited to the anterior portion of the urethra, or it may extend to the posterior portion, or even to the bladder, ureters, and kidneys. The infection may extend to the lymphatics of the penis and of the groin, to the follicles of the prostate gland, and along the vas deferens and seminal vesicle to the epididymis. In the female it may extend from the urethra or vagina to the glands of Bartholini, or to the uterus, Fallopian tubes, ovaries, and peritoneum. It may by means of the blood-channel reach more distant organs, as the fibrous tissues of joints, bursæ, and tendons; or serous membranes, as the pleura, the peritoneum, the endocardium, the joints, the meninges of the brain; and in some cases produces pyæmia. The numerous follicles and pockets in the genital canals of both sexes are affected, and the microbes often remain in them after they have disappeared elsewhere.

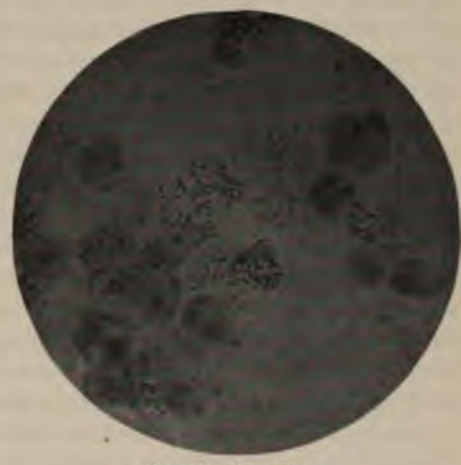

FIG. 272.—Gonococci.

Symptoms.—The period of *incubation* lasts for from a few hours to twelve or fourteen days, in the majority of cases from three to seven days. The patient may first notice a sensation of tickling or itching in the meatus, the lips of which are slightly red and swollen, with a drop or two of thin, milky fluid, and some warmth during urination. In the next forty-eight hours the symptoms become pronounced, with *ardor urinæ*, or scalding urination, frequent urination, and vesical tenesmus, with a small twisted or scattered stream. Frequent urination and vesical tenesmus usually indicate involvement of the posterior urethra. The discharge becomes thick, copious, and of a greenish yellow. The entire organ is swollen and tender and the prepuce œdematous. Chordee, or painful erection with distortion, due to lack of uniform distention of the erectile tissues in the *corpus spongiosum*, is likely to occur, especially at night when the patient is warm in bed. This stage lasts for from five to seven days, and may be complicated by balanitis, balanoposthitis, and phimosis or paraphimosis. The *second stage*, or stationary period, is characterized by a continua-

tion of the symptoms mentioned, lasts for from about one to two weeks, and may be complicated by follicular or periurethral abscess, lymphangeitis of the dorsal lymphatics, bubo,—usually unilateral,—Cowperitis, prostatitis,—which may end in resolution, suppuration, or become chronic,—and cystitis. The *third stage*, or stage of subsidence, lasts for from four to eight weeks, during which the symptoms abate, urination becomes painless and less frequent, the discharge thinner, scantier, and finally ceases. The complications which may occur during this stage are epididymitis, more frequently on the left side, about the fifth week or later; gonorrhœal rheumatism, urethral synovitis, or post-gonorrhœal arthritis, usually in the third or fourth week, preceded by abatement or cessation of the discharge; and gonorrhœal ophthalmia, which may arise at any time from conveying the infection to the eye by means of the fingers, towels, etc.

The *diagnosis* can be positively made only by finding the gonococcus within as well as without the pus-cells in sufficient numbers. It is differentiated from similar cocci by decolorizing with Gram's method. Bum succeeded in causing gonorrhœa by placing in the urethra gonococci from cultures of the twentieth generation.

Subacute or catarrhal gonorrhœa occurs in those who have had previous attacks of gonorrhœa which leave the urethra with a predisposition to the disease; or the germs which have been lying inactive in the follicles of the urethra become suddenly excited to activity by some unusual stimulation, as indulgence in liquor or venery. There is mucopurulent or purulent discharge coming on after suspicious connection or excessive indulgence in venery. Pain and chordee are slight or absent, but gonorrhœal rheumatism and ophthalmia are apt to occur.

Chronic Gonorrhœa.—When the discharge persists after two or three months, it is called *chronic gonorrhœa* or *gleet*. The discharge may be considerable, of a thin milky appearance, or very slight and only perceptible in the morning after stripping the urethra or using a bougie. The lips of the meatus are slightly glued together in the morning, or there may be a drop or two of mucopus. "Tripperfäden"—delicate white filaments like strings—are seen floating in the urine first passed. There is possibly slight scalding on urination, a little pain or ache on erection, but all of the symptoms are apt to become aggravated by excesses. The infection may be located in certain follicles of the urethra where it has remained since the beginning of the disease. Changes in the tissues may have taken place, beginning the formation of stricture.

Simple or *non-specific urethritis* is caused by the action of other pyogenic organisms than the gonococcus. It may be caused by cathe-

terism, the passage of gravel, or exposure to leucorrhœal or acrid vaginal or uterine discharges.

The *symptoms* are similar, but less severe and of shorter duration than those of gonorrhœa, and the gonococcus is absent.

Treatment of Gonorrhœa.—The indications are: To remove all sources of irritation, mechanical or mental; to destroy the germs or inhibit their action; and to treat complications. Put the patient to bed, or at least restrict his activity as much as possible. Envelop the end of the penis in clean absorbent cotton and then place in a bag which is attached to tapes tied around the waist. Renew the cotton frequently. Avoid all constriction of the penis and prohibit the society of females. Give diluent drinks, restrict the diet, and cut off stimulating and highly seasoned food and alcoholics. Bathe the penis in hot salt solution and inject the latter into the urethra two or three times daily. The bowels should be kept open. The abortive treatment of gonorrhœa is delusive, the cases cured having no doubt been simple urethritis. It is claimed that the early use of the permanganate irrigation, 1 to 5000 to 1 to 2000, will cure in from three to six weeks. At least a quart of fluid should be used at each irrigation, once or twice daily. A fountain syringe with a suitable nozzle, or Valentine's or Burr's irrigator, may be used, the receptacle being elevated to a sufficient height to produce enough pressure to distend the urethra fully or to enter the bladder. Argyrol, 1 to 2000 to 1 to 500, may be used in the same way. Nitrate of silver, fifteen grains to the ounce, is sometimes used in the earliest stage, and may have a beneficial effect in killing the germs and limiting the course of the disease. It may be used as a single injection into the anterior portion of the urethra, where it is held for a few seconds and then neutralized by the patient's passing water, or by the injection of salt solution. Often it is best during the acute stage to use no injection except warm water or salt solution. *Per os* give acetate or citrate of potassium with bromide of potassium or tincture of hyoscyamus, and for medicating the urine, salol or urotropin. After the acute stage the balsams may be used,—oil of santal wood, cubebs, or copaiba. Impress the patient with the importance of disinfecting his clothing and fingers, lest the disease be conveyed to his eyes or to other individuals.

FIG. 273.—Burr's irrigating apparatus with stop-pulley.

Treatment of Chronic Gonorrhœa.—The persistence of the discharge after two months is probably due to disease in the follicles of the deep urethra or the existence of ulceration. This may be determined by the urethroscope or by passing a bulbous bougie, noticing the tender localities and the thick white discharge brought out on the shoulder of the instrument. Apply nitrate of silver, 1 to 2 per cent., in solution or ointment, by Ultzman's syringe or a soft-rubber catheter, or by passing a sound smeared with ointment. Protargol (metallic silver combined with a proteid) may be used in the form of bougies introduced into the urethra, in which they melt; or in solution in water, one-half to 1 per cent. Argonin, a combination of albumin, silver, and an alkali, may be used in solution by injection or irrigation, in strength of one-fifth to one-half per cent., or stronger. Potassium permanganate is also a good remedy in chronic gonorrhœa. The passage of a sound once a week may cure when a stricture is beginning to form.

The treatment of simple urethritis consists in removing the cause of the inflammation when possible, then using irrigations of hot water or of weak solution of permanganate of potassium.

Treatment of Complications of Gonorrhœa. — *Chordee.* — Keep the bowels open. Have the patient sleep in a cool room with light cover and lie on his side. Monobromate of camphor, three to five grains, or bromide of potassium, thirty to sixty grains, at night; leeches to the perineum, and applications of cold to the genital organs.

Epididymitis.—Put the patient to bed, elevate the affected organ, apply leeches, guaiacol, tobacco fomentations, lead and opium, or tincture of aconite; and give internally bromide of potassium and tincture of aconite.

Balanitis, balano-posthitis, phimosis, and *paraphimosis* should be treated by strict cleanliness, applications of lead and opium, boracic acid, or bismuth. When possible lint or absorbent cotton should be inserted between the prepuce and glans. *Phimosis* and *paraphimosis* may require slitting up of the prepuce.

Cowperitis and *acute prostatitis* should be treated by urethral or rectal injections of hot water. If pus forms, it should be evacuated by an incision in the perineum.

For *ophthalmia* apply a 2 per cent. solution of nitrate of silver, washing out after a few seconds with solution of salt. Put the patient in a dark room, keep the pupil dilated with atropin, and wash out the eye several times daily with warm borate of sodium solution. Protect the other eye from infection.

For retention of urine give hot hip-baths and warm enemata. If these fail, introduce a soft catheter, or if necessary a silver one.

Suprapubic aspiration of the bladder may in some rare cases be required.

Duration of Gonorrhœa. — Few cases of genuine gonorrhœa are cured, so that the patients cannot convey the disease, in less than six months. Many of them persist for a much longer period, even for years, the disease continuing in the follicles of the deep urethra or of the prostate gland, in the seminal vesicles, or in the joints as rheumatism. There may be no visible symptoms in the urethra, or they may be so slight as not to attract attention until after some excess. During all this time the patient is a menace to any one with whom he may have sexual relation.

STRICTURE OF THE URETHRA.—Stricture of the urethra is an abnormal diminution of the calibre of the urethra, temporary or

FIG. 274.—Paraffin casts of normal urethræ. (Gerster.)

permanent. There are three varieties: Inflammatory, spasmodic, and organic.

Inflammatory stricture is a condition sometimes seen in cases of acute urethritis due to swelling of the walls of the urethra to such an extent that the passage of water is prevented. *Spasmodic stricture* is caused by contraction of the muscular fibres of the urethra, either the circular fibres of the urethra or the compressor urethræ muscle. It is an evidence of inflammation, or of irritation, as organic stricture, attempts to pass urethral instruments, or excesses in eating and drinking. *Organic stricture* is the true form of stricture, and is caused by more or less permanent changes in the tissues of the urethra as a result of inflammation.

The varieties of organic stricture are: *Linear*, *annular*, *tortuous*, or *tubular*, *irritable*, and *resilient*. According to *size*, they may be divided into *strictures of small calibre* which do not admit instruments larger than No. 15 French, and *strictures of large calibre* which admit instruments above this size.

The most common *site* of stricture is in the bulbomembranous portion; next, the first two and one-half inches from the meatus; and, third, the middle of the spongy portion of the urethra.

The *causes* are congenital defects, traumatism, and disease.

Congenital defects produce narrowing of the urethra from the failure of complete removal of the partition which separates the penile from the glandular portion of the urethra in fetal life.

Rupture or *laceration* of the urethra may be followed by stricture. *Inflammation* of any kind may be followed by stricture, but the large majority of cases are due to *gonorrhœa*. As a result of inflammation an increased amount of connective tissue is formed in or beneath the mucous membrane, which may occlude the urethra by filling up the channel, or diminish its calibre by contraction; the urethra posterior to the stricture becomes dilated; a few drops of urine may lodge and decompose, destroying the mucous membrane, with resulting extravasation of urine and the formation of abscesses, which may open on the surface in the perineum, or elsewhere along the course of the urethra.

Symptoms.—A gleety discharge, which continues long after a previous attack of gonorrhœa; increased frequency of urination by night as well as by day, with diminution in size and force of the stream of water; dribbling at the end of urination, and inability to completely empty the urethra; and certain nervous symptoms, as hypochondria, may appear, or, later on, perineal abscess, fistula, or diseases of the ureter and kidneys. The *diagnosis* must be made by examining the urethra with a sound, or, better, a *bougie à boule*. Do not mistake the normal contraction and the hitching of the shoulder of the instrument at the posterior layer of the triangular ligament for stricture.

Extravasation of urine, which often occurs as a result of impassable strictures, is indicated by swelling and œdema of certain localities, depending on the point of rupture in the urethra. If the rupture occur in the region of the *bulb* in *front* of Colles's fascia (the deep layer of the superficial fascia), the swelling and œdema show in the scrotum and penis. In rupture in the bulbous portion *behind* Colles's fascia, and in front of the anterior layer of the triangular ligament, the urine cannot go backward or to the side, so it passes in front into the scrotal tissues and up between the spine of the pubes and the symphysis on the abdomen. Rupture *between* the *two layers* of the

triangular ligament permits the escape of urine externally only after suppuration and sloughing. Rupture of the prostatic urethra *behind* the *triangular ligament* allows extravasation into the tissues by the rectum, and the urine may appear in the perineum, or it may dissect up the pelvic fascia and get beneath the peritoneum.

Treatment of Stricture.—Treat strictures of large calibre, above No. 15 French, situated in the bulbomembranous urethra, by gradual dilatation. Treat strictures of large calibre in the pendulous urethra by gradual dilatation when practicable, or by internal urethrotomy. Treat strictures of the meatus and vicinity by meatotomy and the passage of sounds. Treat strictures of small calibre, less than No. 15 French, in front of the bulbomembranous region, by dilatation when practicable, or by internal urethrotomy. Treat strictures of small calibre in the bulbomembranous region by dilatation if a No. 9 or a No. 10 French can be passed, otherwise by perineal section or external urethrotomy. Treat strictures of the deep urethra, permeable only to a filiform, by passing a Banks filiform

Fig. 275.—Banks's dilating filiform bougies.

bougie, followed by gradual dilatation, by internal urethrotomy, or by external urethrotomy. Internal urethrotomy in this region is often unsatisfactory, and, if dilatation fail, external urethrotomy or perineal section is a safer and more satisfactory operation. Impassable strictures must be treated by perineal section without a guide, the Wheelhouse method being the best.

The Wheelhouse Operation.—With the patient in the lithotomy position pass a sound into the urethra as far as the stricture; make an incision through the perineum, opening the urethra on the sound about one-quarter of an inch *in front* of the stricture; and pass a silk thread through each edge of the slit urethra. Withdraw the sound, pull open the urethra by means of the threads, and endeavor to find the opening through the stricture by the use of a probe or grooved director. Sometimes pressure on the bladder will force out a drop or two of urine and show the opening. Introduce a grooved director, divide the stricture with the knife, and dilate it with the finger or sound to full size. A soft catheter may be introduced through the

wound into the bladder, and left in place two or three days. The after-treatment consists in the passage of sounds from the meatus to the bladder at regular intervals, the first sound being passed on the second day after the operation and twice a week afterwards for a month, then at longer intervals. In case of failure to find the urethra, if the patient's condition will permit, a suprapubic cystotomy may be performed and the sound passed from the bladder through the urethra. After dividing the stricture, the suprapubic wound may

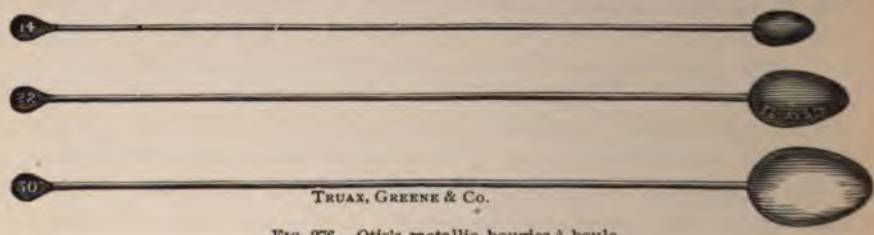

FIG. 276.—Otis's metallic bougies-à-boule.

be closed completely, but a catheter should be kept in the bladder until the suprapubic wound has completely healed.

Internal Urethrotomy.—For internal urethrotomy the two instruments most frequently employed are the urethrotomes of Otis and of Maisonneuve. Otis's urethrotome is a dilating instrument and cuts from behind forward, so that it is necessary to pass the instrument through the stricture before cutting it. Maisonneuve's urethrotome, on the other hand, cuts from before backward, and can be used to divide strictures which are too tight for Otis's instrument by first passing a filiform bougie, screwing the end of the Maisonneuve in-

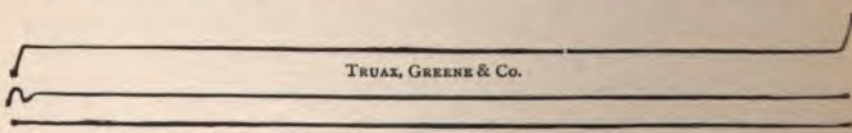

FIG. 277.—Goulay's whalebone filiform bougies.

strument on it, then pushing the instrument through the stricture, being guided by the filiform bougie, which curls up in the bladder. Otis's instrument is used as follows: A general anæsthetic or cocaine is necessary. Introduce the instrument until the blade is a quarter of an inch behind the stricture, which has previously been located by means of a bulbous bougie. Turn the screw in the handle and distend the urethra, the degree being indicated by a hand on a dial-plate on the handle of the instrument. With the urethra distended withdraw the blade, dividing the stricture from a point a little be-

hind to a point a little in front of the stricture. The blade is then pushed back into its slot and the urethra again dilated, this time to its full capacity, provided too much force is not needed; otherwise the stricture may be cut in one or two more places and successively

Fig. 278.—Otis's straight dilating urethrotome.

dilated till full size is reached. The blade is then pushed home into its slot and the instrument withdrawn with the blades not completely closed, lest the mucous membrane be caught and lacerated. A full-sized steel sound is passed at once and at regular intervals afterwards. Excessive hemorrhage may be controlled by compressing the penis with the hand; by introducing a full-sized rubber catheter and

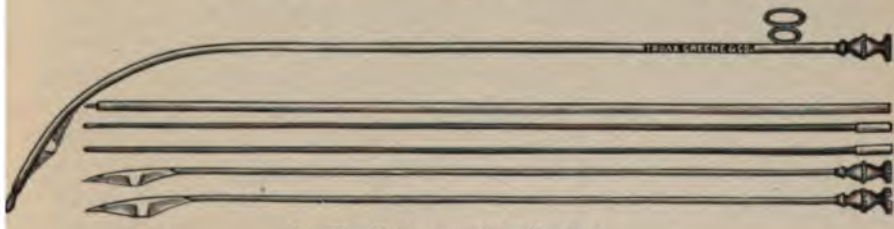

Fig. 279.—Maisonneuve's urethrotome.

applying a bandage firmly to the penis over the catheter; or the bandage may be applied without the use of the catheter.

Perineal or urethral fistulæ are cured by the operation for the cure of the stricture, either dilatation or external urethrotomy. If they persist after relief of the stricture, stimulate the tissues with nitrate of silver, or open the urethra through the fistula and dissect out the fistulous track.

Urethral Fever.—This is the name given to the fever which sometimes follows operations on the urethra, or simply the introduction of a sound or catheter into the bladder. It is thought to be a toxæmia, from infection introduced or which already existed in the urethra, or a form of nervous irritation.

Symptoms.—The symptoms come on often during the first urination, from a few moments to several hours after the operation, with a *chill* or *rigor*, followed by *fever*, possibly suppression of the urine, and

septicæmia or pyæmia, and sometimes death in less than twenty-four hours.

Introduction of a Catheter or Sound.—In the first place, see that the instrument has the proper curve and that it and the end of the penis have been disinfected. Place the patient on his back, with the shoulders elevated, in order to relax the muscles. Stand on the patient's left and take the instrument, warmed and lubricated with sterile glycerin or oil, in the right hand, while the penis is held in the left hand. With the instrument held parallel with the line of the left groin, introduce its point into the mouth of the urethra and gradually draw the penis up on the instrument, rather than push the instrument into the urethra. The handle of the instrument is kept in this position, nearly touching the patient's body, until its progress is arrested; the handle is then turned to the median line, gently and slowly elevated until vertical, pushed onward and gradually depressed between the thighs, aided by pressure with the left hand on the perineum, until its point enters the bladder, as indicated by the freedom of motion which can be given the end of the instrument when the handle is rotated. The tip of the instrument is most likely to be arrested in front of the triangular ligament, either from raising the handle too soon or from not raising it soon enough. In either case do not use any force, but withdraw the instrument a short distance and try again. In selecting an instrument for the first trial, always select one of medium or large size, as a large instrument will often pass without trouble when a smaller one would hang up in a false passage or in a pouch of the urethra.

INJURIES AND DISEASES OF THE TESTICLES, SPERMATIC CORD, AND SEMINAL VESICLES.

Congenital Anomalies.—Both testicles may be entirely absent (cryptorchidism) or only one may be lacking (monorchidism); the organ may be reversed in its position in the scrotum, the epididymis being turned to the front; but the most common anomaly is an arrest of the descent of one or both organs from the fetal position near the kidney to the scrotum. Usually only one side is affected, and the arrest may occur within the abdomen, in the inguinal canal, or just outside of the external abdominal ring. Sometimes the testicle lodges in the perineum or the groin. It is often associated with congenital hernia, and is apt to be undeveloped or atrophied.

When located within the abdomen, no *treatment* should be attempted unless the organ becomes diseased. When located in the inguinal canal or at the external abdominal ring, an attempt may be made to bring it down to its normal position by exposing the organ,

dividing all the tissues of the cord which prevent its descent, except of course the vas deferens and its vessels, and stitching it to the bottom of the scrotum.

INFLAMMATION OF THE TESTICLES.—*Epididymitis* may be caused by injury, infection from the use of instruments, or most commonly from gonorrhœa. *Orchitis* (inflammation of the body of the testicle) may be caused by injury, by infection from gonorrhœa, tuberculosis, typhoid fever, or syphilis, or by metastasis in pyæmia or mumps.

Symptoms.—The disease may be *acute* or *chronic*, and when acute the pain is severe, of a nauseating character, and radiates towards the groin, hip, and back. The pain is diminished by the recumbent position and by elevation of the organ. On examination the testicle is found uniformly enlarged, of oval form and smooth surface, thereby differing from epididymitis, which is felt as a hard protuberance on the posterior surface of the testicle. *Syphilitic orchitis* is sometimes bilateral and is usually painless. *Tuberculous orchitis* is rare except when it follows tuberculosis of the epididymis. It is often bilateral and occurs between the ages of twenty and forty years. The epididymis becomes hard, with bead-like swelling, with little or no pain. The swellings break down, become adherent to the skin, discharge, and produce sinuses. The seminal vesicles, the vasa deferentia, the prostate, and the bladder are apt to become involved.

Treatment.—For *acute orchitis* put the patient to bed, elevate the testicle and apply an ice-bag; give a purgative and keep the bowels open. If an abscess form, open it at once by a small incision, lest a hernia testis with loss of the organ result. For *syphilitic orchitis* give mercury and iodide of potassium. If the enlargement is slow in subsiding, strap the testicle with adhesive plaster in order to exert a uniform pressure upon it. A suspensory bandage should be worn, except when the patient is in bed. In *tuberculosis of the epididymis*, excise the epididymis and vas deferens, also the testis if involved. If the disease has extended to the seminal vesicles or the prostate, it may be necessary to remove them.

INFLAMMATION OF THE SEMINAL VESICLES is most frequently the result of infection from gonorrhœa or tuberculosis. As a result of gonorrhœa it is apt to be a chronic condition, often difficult to cure.

Symptoms.—Pain of a dull aching character, felt in the rectum, the neck of the bladder, the penis, in the back or thighs, and aggravated during defecation, urination, or sexual excitement. Sexual desire may be increased or in some cases diminished or destroyed. There may be priapism and a slightly bloody discharge from the urethra. Neuroses are apt to be present, the patient suffering from mental depression, with loss of flesh, strength, and appetite. A slight

gleety discharge from the urethra may be present, or it may only be brought on by stripping the seminal vesicles. Rectal examination discloses a hard, tender mass above the prostate on one or both sides.

Treatment.—Treat posterior urethritis when present. Give enemata of hot water two or three times daily and strip the ducts of their contents about once a week. Fuller's method is as follows: With his bladder full the patient leans over a table or chair-back with his knees straight and his body at a right angle. The surgeon introduces one finger into the rectum, while with the other hand pressure is made on the bladder above the pubes in order to bring the vesicles within reach. The operation of removing the vesicles may be performed by a curved incision across the perineum between the rectum and urethra. *Van Dittel* makes an incision from the base of the coccyx around one side of the anus to the perineum. The coccyx and last sacral vertebra are removed and the levator ani muscle on that side is divided. The vesicles are then sought by carefully separating the tissues by blunt dissection, avoiding the ureters, being guided by the upper or posterior border of the prostate gland. The vesicles lie to the outer side of the vasa deferentia and posterior to the ureters. Young removes the vesicles and if necessary the prostate by a suprapubic operation, as follows: Make a transverse incision through the recti muscles just above the umbilicus in the linea transversa, and a longitudinal incision between the recti down to the pubes. The peritoneum is separated from the summit and posterior wall of the bladder until the vasa deferentia are found. These are traced downward until the vesicles are found and removed. The operation is entirely extraperitoneal.

TUMORS OF THE TESTICLE.—The most common tumors of the testis are chondroma, sarcoma, carcinoma, and dermoid or retention cysts.

CARCINOMA of the testicle is usually of the soft or *encephaloid* variety and occurs most frequently in persons under forty-five years of age, beginning as a smooth swelling of the body of the testicle, which soon becomes nodular and involves the epididymis.

The *diagnosis* is made from *tuberculosis* of the testis by the rapid growth and enormous size of the tumor; by its beginning in the *body* of the testicle, while tuberculosis begins in the epididymis; by the pain being severe and lancinating, while in tuberculosis there is little or no pain. *Syphilitic orchitis* is recognized by its slow growth, the regular outline of the tumor, absence of tendency to involve the skin or to ulcerate, and the slight amount of pain.

SARCOMA OF THE TESTICLE.—All varieties of sarcoma are found in the testicle, but the most common is the round-celled. Of 113

cases 65 per cent. were composed principally of round cells and over 60 per cent. occurred in persons under forty years of age (George M. Kober).

Symptoms.—It begins in the body of the testicle as a rapidly-growing tumor, of regular shape at first, but soon developing protuberances which are soft and cystic in some places and cartilaginous in others. The blood-vessels of the scrotum are swollen and enlarged, but ulceration of the skin does not occur until late, except in the soft and most malignant varieties. There is little pain—only a feeling of weight. The inguinal glands are often affected, and metastases are apt to occur in the lungs and other organs. The disease is usually unilateral, but may be bilateral.

The *diagnosis* is made from *hydrocele* and *hæmatocele* by the rapid growth, irregular outline with areas of different consistency, the enlarged veins of the scrotum, and, later, the tendency to ulceration. From *cyst* of the testicle the diagnosis is sometimes difficult.

Treatment.—All tumors of the testicle should be removed, but when benign the entire organ need not be sacrificed, except in cases of *chondroma*, which should be treated as sarcoma—into which it may degenerate. In *cancer* and *sarcoma* early and radical operation is the only hope for the patient. In all cases remove the inguinal glands and excise the cord well up into the inguinal canal.

Of Kober's 113 cases operated on, 41 died in from a few days to three years after the operation.

Castration.—The incision will depend upon the size of the tumor and whether or not the skin is involved, and should always be made through healthy tissue at a safe distance from and so as to remove all the diseased parts. When the tumor is small and the scrotum free from disease, the testicle may be removed through a small incision over the external abdominal ring. Make the incision through the skin and fascia until the cord is exposed. Draw the testicle through the wound, make traction on the cord, transfix and ligate it with strong catgut, and remove the testicle. Stop all hemorrhage and close the wound without drainage.

HÆMATOCELE.—Hæmatocele is an accumulation of blood in the sac of the tunica vaginalis testis. It is nearly always the result of injury which causes laceration of the blood-vessels, but may occur as a result of strangulated omental hernia or of disease. It may follow strains or tapping for hydrocele. It may be mistaken for hernia or hydrocele. It appears as a more or less pyriform tumor, with the base below, and may be fluctuating or elastic, but is not translucent, and there is usually a history of injury.

Treatment.—In recent cases put the patient to bed, elevate the

scrotum, and make cold applications. After a few weeks absorption of the effused blood may be hastened by strapping the tumor. If in spite of this the tumor fails to disappear, or is accompanied by disagreeable symptoms, open the tunica vaginalis, evacuate the blood, and close the wound with drainage.

HYDROCELE.—Hydrocele means a collection of water in a sac, but unless otherwise stated it is usually understood to mean a collection of watery fluid in the tunica vaginalis testis or in the funicular process of the cord. The fluid is usually straw-colored, has almost the same composition as blood serum, and may contain cholesterine crystals. Hydrocele may be *acute* or *chronic*, nearly always the latter, and may affect the *testicle* or the *cord*.

Hydrocele of the Testicle.—1. *Acquired* or *ordinary*, where the fluid accumulates in the tunica vaginalis testis. 2. *Congenital*, in which the cavity containing the fluid communicates with the peritoneal cavity on account of the existence of a patulous funicular process. 3. *Infantile*, in which the fluid fills the tunica vaginalis and extends up the cord as far as the external abdominal ring, the funicular process having been obliterated at this point, but not at the testicle. 4. *Encysted hydrocele*, which is really a collection of cysts in connection with the epididymis beneath the tunica vaginalis. 5. *Bilocular* hydrocele, which consists of two sacs of fluid communicating by a small opening, as the funicular hydrocele which communicates below with a hydrocele of the tunica vaginalis. Sometimes the superior sac extends through the inguinal canal to the internal ring, or beyond that point between the peritoneum and the transversalis fascia. 6. *Fatty* or *milky hydrocele*, in which the fluid has the appearance of milk or chyle, being the result of leakage from the lymphatic vessels, which are obstructed by inflammation or the presence of the filaria sanguinis hominis.

Hydrocele of the cord may be: 1. *Congenital*, in which the funicular process is obliterated just above the testicle, but is open above; and the water fills this space, which communicates with the general peritoneal cavity. 2. *Encysted*, in which the funicular process is obliterated both below at the testis and above at the external abdominal ring, but the space between remains unobliterated, and the fluid accumulates therein. The sac may be *multiple*, owing to adhesion at several points along the cord.

Hydrocele may be *unilateral* or *bilateral*, and the quantity of water varies from a few ounces to one or two pints. It may occur in the female in the canal of Nuck.

Causes.—Hydrocele is usually caused by traumatism or inflammation of the peritoneum which forms the tunica vaginalis and the

funicular process. It may accompany orchitis, epididymitis, tuberculosis, or new growths of the testis. In old cases the sac becomes thick and tough and is often studded with fibrinous or calcareous particles.

Symptoms.—Hydrocele of the tunica vaginalis begins as a swelling at the lower portion of the scrotum in front of the testicle. The swelling gradually increases in size from below upward, is tense and fluctuating, but, when very tense, fluctuation may be imperceptible. It is dull on percussion, and is not tender nor painful. It is usually pyriform in shape, with the base below, but sometimes the base is above. The tumor is translucent, except in the negro race or in those containing bloody fluid or having thick walls. The *congenital* form of hydrocele may be recognized by the fluid disappearing on lying down and by its failure to return on standing when the finger is kept firmly pressed over the external ring.

The *diagnosis* may be confirmed by drawing off some of the fluid with a hypodermatic syringe. From *hernia* hydrocele is distinguished by the absence of impulse on coughing; by its irreducibility, except the congenital form; its translucency; by its not projecting into the inguinal canal, except the congenital form; and by the history of its beginning.

Treatment.—Simple evacuation of the fluid by trocar and cannula or aspirator is nearly always followed by recurrence. *Radical treatment* aims at abolishing the sac of the tunica vaginalis, either by adhesive inflammation or by removal.

Injection Method.—After thorough disinfection of the scrotum, grasp the testicle with the left hand, so as to make the skin tense in front; insert a large aspirating needle into the front of the tumor, taking care not to injure the testicle, and let the fluid escape; attach a syringe to the needle, and inject from ten to thirty minims of 95 per cent. carbolic acid solution into the empty sac; remove the needle, and manipulate the sac so as to spread the liquid over its entire surface. Keep the patient in bed for a day or two, and then permit him to go about with a suspensory bandage. Considerable swelling follows, but this usually subsides in two or three weeks, and a permanent cure may result.

Von Bergmann's Method.—Make an incision extending from one end of the tumor to the other down to the parietal layer of the tunica vaginalis; peel off the scrotum and fascia until the tumor is exposed; open and excise the sac by cutting it off near the margin of the testicle, and close the incision with drainage. This is the surest method of curing hydrocele.

Congenital hydrocele may be cured by wearing a truss; but if this

fail, expose and divide the funicular process as in an operation for inguinal hernia, and close each end with sutures or ligature.

VARICOCELE.—Varicocele is a varicose condition of the spermatic cord, usually limited to the pampiniform plexus; occasionally the veins accompanying the vas deferens are also involved. It occurs probably in 10 per cent. of all males, usually about puberty, and nearly always on the left side, from the greater length of the left spermatic vein, its entrance into the renal vein at right angles, and from the pressure on it of the sigmoid flexure in constipation. Other causes are straining, as in defecation or urination, and sexual excesses in thought or deed.

Symptoms.—The scrotum is usually elongated, attenuated, and contains a mass of blue veins which on palpation give a sensation like a bunch of worms. On lying down the tumor disappears, to return again on assuming the erect posture, although the finger may be pressed over the external ring. Atrophy of the testicle may result from pressure. A sensation of weight or dull pain may be felt in the testicle or loin, and sexual hypochondria is often a prominent symptom, the patient being despondent as to his virility. Hernia and hydrocele must be remembered, but are easily excluded by the symptoms given.

Treatment.—In young patients in which the varicocele is slight and gives little inconvenience, operation is unnecessary. Advise the patient to wear a suspensory bandage, avoid constipation and erotic thoughts, with the assurance that he will recover as he grows older. If there is wasting of the testicle, much pain, or marked hypochondria, or the patient desires to enter one of the public services to which his affection is a bar, a radical operation is indicated.

Passing over the various methods of subcutaneous ligation, which are uncertain as well as dangerous, sometimes to the surgeon as well as to the vas deferens, the best method is *ligation and excision*. The parts are shaved and thoroughly disinfected. General anæsthesia is usually necessary, but the operation may be done under cocaine. Make an incision about two inches long over the external abdominal ring, through skin and fascia, until the veins are exposed. Keep the vas with its venous plexus out of the way. Ligate the dilated veins with catgut at the upper part of the incision and again at the lower part near the testicle, excise the section about one inch in length between the ligatures, and suture the stumps together. Arrest all hemorrhage, close the wound without drainage, and apply a dressing with the testicle well elevated. The patient is usually well in two weeks. A safer method is to exclude the spermatic artery and at least one vein of the pampiniform plexus from the ligatures, as atrophy of

the testicle may follow division of *all* the veins and arteries except those accompanying the vas. When the scrotum is very long and pendulous, it may be shortened by cutting off the lower part and closing the wound with sutures.

IMPOTENCE.—Impotence is inability or want of power to perform the sexual act. The causes are: Malformations; absence or diminutive size of the penis; disease or injury which destroys the erectile power or produces premature ejaculation, such as stricture; abscess or inflammation of the erectile tissue or of the prostate gland and appendages; disease of the cerebrospinal axis, especially of the lumbar cord; and, probably, the excessive use of tobacco.

Treatment.—The case should be carefully studied and the cause determined and appropriately treated. Complete rest from sexual indulgence and treatment of prostatitis or vesiculitis may be necessary.

STERILITY.—Sterility—literally unfruitfulness—means the inability to fecundate. The *cause* of sterility lies with the male in about 10 per cent. of cases. These causes may be: Defect in the spermatic fluid from the absence of living spermatozoa; orchitis or tumors producing atrophy or destruction of the testicle; obstruction of the ducts in the epididymis, vas deferens, seminal vesicles, the prostate or urethra, from inflammation or growths affecting both sides; and sexual excesses or general debility after illness. The *diagnosis* of sterility may be made by the microscope, failing to find living spermatozoa.

Treatment.—Inflammatory conditions and excesses require appropriate treatment. In many of the cases little can be done.

INVOLUNTARY SEMINAL DISCHARGES AND SPERMATORRHŒA.—Involuntary emissions occur normally at intervals of from ten to thirty days and do not indicate disease.

Spermatorrhœa is the escape of seminal fluid without orgasm or erotic thoughts, usually at the end of defecation or micturition, and may result from masturbation or inflammation of the prostate or posterior urethra. The seminal is distinguished from the prostatic fluid by the use of the microscope.

Treatment.—Remove the cause and treat inflammation of the prostate or urethra when it exists, allay the morbid fear which is often a prominent symptom, and enforce strict hygienic measures.

INJURIES AND DISEASES OF THE PENIS.

CONGENITAL ANOMALIES consist of entire absence (very rare), misplacement of the organ beneath the skin of the scrotum or perineum, or it may be rudimentary or multiple. The urethra may be

entirely absent, it may contain pouches of considerable size, or it may be defective in part, producing *hypospadias* and *epispadias*.

Hypospadias is a deficiency of the lower wall of the urethra, so that the urethra opens posterior to its normal position,—in the perineum, when the scrotum is usually divided, having failed to unite; at the anterior fold of the scrotum; or at any point in the penile portion of the urethra or in the glans (balanic hypospadias). The last is the most common variety.

Treatment.—Duplay's operation: 1. Straighten the organ by making transverse incisions through the skin, if this be involved; otherwise, subcutaneously. Unite the parts longitudinally, and fix the penis in the straight position until healing takes place. Make the meatus by an incision through the depression, which usually exists where the opening of the urethra should be, deep enough for the insertion of a rubber catheter, over which the lips of the glans are united. A period of several months must then elapse until the organ is in condition for the second step. 2. Make two longitudinal incisions, one on either side, from the base of the glans to the hypospadiac opening and from each end of these make a transverse incision towards, but not quite to, the median line. The flaps thus outlined are each dissected up about half-way towards the median line, turned inward, and united by fine silk sutures over a gum or rubber catheter. The outer flaps to the outer side of the longitudinal incisions are likewise dissected up until the flaps can be brought together, and united in the median line over the first set of flaps. The anterior extremity of the tube thus made is united by sutures to the freshened base of the glans, thus leaving to complete the operation the repair of the hypospadiac opening. Several months more are allowed to elapse for recovery from this operation. 3. The hypospadiac opening is freshened and united over the catheter. Considerable skill, patience, and repeated operations are usually necessary in order to get a satisfactory result.

Epispadias is an absence or defect of the upper wall of the urethra, and may be treated by an operation corresponding to that for hypospadias. It is often associated with exstrophy of the bladder.

INJURIES OF THE PENIS.—*Fracture* of the penis is the result of violence to the organ while in a state of erection. The corpora cavernosa or corpus spongiosum and erectile tissue are lacerated, and sometimes a hæmatoma is formed. The *treatment* consists in cold applications, and, if the hemorrhage threatens to result in suppuration or in gangrene, incisions should be made. Recovery with deformity is apt to follow.

Dislocation of the penis is a separation of the organ from the skin

in which it is enclosed, and its displacement beneath the skin of the pubes. In recent cases the organ may be restored to its normal position by manipulation, but in old cases dissection may be necessary.

PHIMOSIS.—Phimosis is a congenital or acquired contraction of the orifice of the foreskin so that retraction behind the glans is difficult or impossible. In infants the opening is usually small, and the foreskin is adherent to the surface of the glans, but the opening becomes larger, and the adhesions separate as the child gets older. Phimosis interferes with cleanliness, favors the contraction of venereal disease, and, from the irritation kept up by the accumulation of *smegma*, may produce nervous symptoms,—chorea, epilepsy, or nocturnal incontinence of urine. The *treatment* is circumcision.

PARAPHIMOSIS is a catching of the foreskin behind the glans after retraction so that it cannot be returned by the patient to its normal position. Swelling, œdema, and even gangrene and sloughing may occur; or if long kept up an increase of connective tissue, resembling elephantiasis, sometimes results.

Treatment.—To reduce a paraphimosis, take the organ behind the constriction between the thumb and first two fingers of the left hand, and with the thumb and forefinger of the right hand compress the glans, and push it back while at the same time the skin is drawn forward. The constricting band is often sunk in a deep wrinkle or groove, and requires division before reduction is possible. This may be done upon a grooved director, or without the director, cutting carefully down in the median line of the dorsum until the constriction is divided. To prevent recurrence circumcision should be performed.

Circumcision.—The operation may be done under cocaine. Attach three pairs of hæmostats to the foreskin, one on either side and one at the frænum, in order to put the inner layer of the foreskin on the stretch. Draw the foreskin forward and cut it off just in front of the meatus with scissors or knife. The skin retracts behind the glans and leaves the latter partly covered by the mucous membrane of foreskin. This mucous membrane should be slit back to the corona and trimmed off at the sides and beneath, leaving enough to cover the glans half-way. The mucous membrane and the skin are next stitched together with catgut. A strip of iodoform gauze is then wound around the organ, leaving the meatus exposed sufficiently for urination. A condom with an opening cut in the end may be put on to keep the dressings in place (Park). The parts usually heal within ten days or two weeks.

TUMORS OF THE PENIS.—The most common tumors are *papilloma* and *epithelioma*. Epithelioma occurs most frequently on the glans

or inner side of the foreskin of men past forty-five, beginning as a wart or chronic ulcer, sometimes the result of syphilitic lesions.

The *diagnosis* is made by the ulcerated surface, the foul discharge, the tendency to break down and bleed, the induration, the tendency to spread rapidly and destroy adjacent parts, and, later, enlargement of the lymphatic glands.

Treatment.—When the disease is confined to the end of the prepuce, circumcision may be sufficient. If the glans is involved, the penis should be amputated about an inch behind the diseased part. If the cancer involves the *corpora cavernosa* or *corpus spongiosum*, the entire organ should be extirpated.

Amputation.—Divide the skin by a circular incision about an inch anterior to the proposed section of the body of the organ. Retract the flap, and divide the corpora cavernosa, then the corpus spongiosum and urethra, leaving the latter somewhat longer than the former. Arrest all hemorrhage, unite the skin flap in a vertical direction over the stump, bring the urethra through the lower portion of the wound, and attach it to the skin on either side after slitting it slightly in a vertical direction.

Extirpation.—Divide the scrotum in the median line, and dissect off the tissues until the corpus spongiosum and corpora cavernosa are exposed. Cut the suspensory ligament just below the pubic arch, pull the penis downward, and detach the crura from the rami with a periosteal elevator. Divide the urethra, bring the proximal end out, and stitch it to the skin of the perineum. From four to eight vessels may need ligatures. The scrotum is then united, and a dressing applied. In any operation for cancer of the penis, the inguinal glands on both sides should be removed.

CHAPTER X.

TUMORS OF THE BREAST.

ADENOFIBROMA.—This is a fibrous tumor containing more or less glandular tissue. It is usually encapsulated, and has no direct connection with the glandular structure of the breast.

Symptoms.—Adenofibroma occurs most frequently between the ages of twenty and thirty-five years, as a slow-growing, painless, firm tumor, usually single, but sometimes multiple. Occasionally it is tender to pressure, neuralgic pain may be felt, and it may be soft or fluctuating from cystic changes. The tumor varies in size from a marble to an orange, or even larger, and may involve the entire breast.

The *diagnosis* is made from *abscess* and *malignant* growths, by the absence of the usual signs of inflammation and of marked tenderness, and by its slow growth and mobility.

Treatment.—Such tumors should always be removed as soon as practicable, not only to relieve the patient's apprehensions, but also to prevent malignant degeneration, which sometimes occurs.

CARCINOMA.—Of the organs of the body most liable to cancer, the breast stands third on the list, the uterus and the stomach being first and second respectively.

The varieties are: Scirrhus, encephaloid, colloid, and epithelioma. The most common variety is scirrhus. Mammary carcinoma is more frequent in the female, in the proportion of about one hundred to one. It may occur as early as at twenty years of age, or as late as seventy, but is most frequent about the menopause. Other things being equal, women who have borne children are more liable to cancer, probably on account of the injury to the breast resulting from infection or inflammation incident to motherhood. There is no doubt that traumatism, as a bruise or contusion, is often the exciting cause, and it is probable that inflammation affecting the glandular and connective tissue acts in the same way. The upper outer quadrant of the breast is most frequently affected with cancer, the region of the areola coming next (Gross).

Symptoms.—Scirrhus begins as a hard, nodular growth, immovable except with the breast. At first it grows slowly, and gradually involves the pectoral muscle and skin, to both of which it becomes firmly attached. Retraction of the nipple occurs in the majority of

cases from contraction of the fibrous trabeculæ which pass between the nipple and the gland, or from direct infiltration of the nipple itself with cancer cells. Sometimes there is a discharge of a bloody, serous, or milky character from the nipple. The skin becomes adherent to the tumor in about fifteen months (Gross), and soon after ulcerates, producing a fungous, bleeding ulcer. In the first stages pain is slight and often neuralgic; later it is severe and cutting, darting, or burning in character. The lymphatic glands of the nearest axilla, and sometimes those of the neck, become involved at an early period, but are not always perceptible to the touch. Cachexia appears after a while, and metastases may occur in the lungs, liver, bones, brain, and other organs. Pressure of the axillary glands on the axillary vein or lymphatics of the arm may cause œdema and enormous swelling of the arm and hand. Death occurs in about two and one-half years.

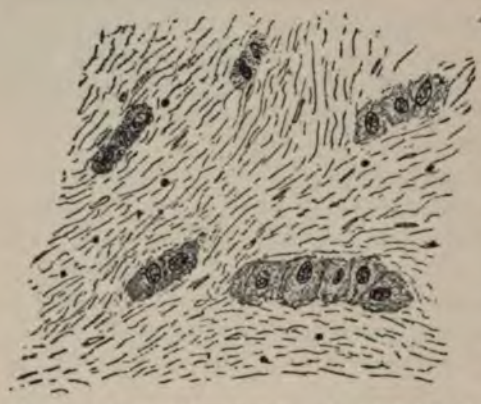

FIG. 280.—Scirrhus of breast, × 400. (F. C. Wood, M.D., in Wharton and Curtis.)

Encephaloid cancer occurs as a deep-seated, rounded, elastic, fluctuating tumor which grows with great rapidity, sometimes reaching the size of a child's head, becomes fixed to the pectoral muscles and chest at an early period, and soon breaks down and forms ulcers containing large red or pale granulations which are prone to slough and bleed. Without treatment death usually results in about one year.

Atrophic or withering scirrhus is that form of cancer in which the fibrous tissue is very much in excess of the cells, being almost pure fibrous tissue. It is the least malignant of carcinomata, growing slowly and perhaps lasting many years. It is recognized by the small size of the breast, which shrinks instead of enlarging, and the skin is adherent to the tumor, which is very hard. Ulceration and lymphatic infection usually occur at a late period.

Recurrence after removal of cancer may be manifested *locally*, when the disease shows itself in the scar or its immediate vicinity, due to the fact that the growth was not completely removed, but some of its branches were left; as *regional* recurrence, when it appears first in some neighboring region, as the axillary or cervical glands; and *general* recurrence, when metastases form in the

internal organs, the lungs, liver, and others giving evidence of the disease.

Diagnosis of Carcinoma.—Cancer is distinguished from *benign* tumors of the breast by its hard and irregular shape; by its rapid growth; by its tendency to become adherent to the skin; by retraction of the nipple (this may occur in benign tumors); by the tendency

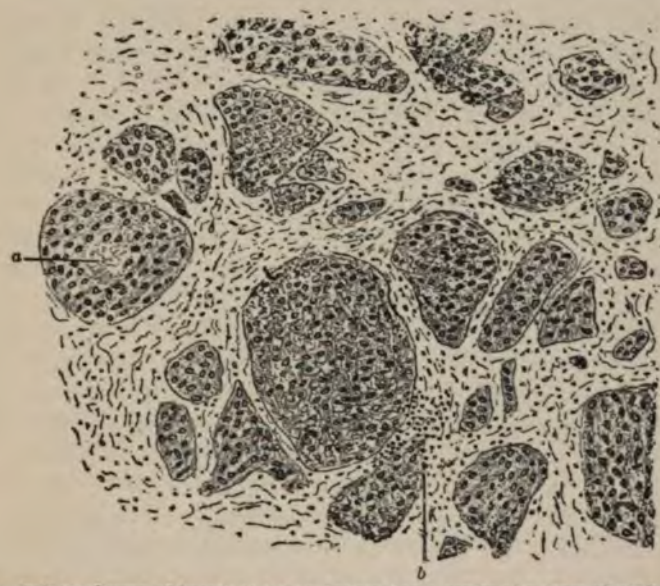

FIG. 281.—Soft carcinoma of breast, × 150: *a*, broken-down centre of a mass of epithelial cells; *b*, small round-cell infiltration of stroma. (F. C. Wood, M.D., in Wharton and Curtis.)

to ulceration; by its becoming fixed to the chest wall; by the prominence of pain as a symptom; and by the involvement of the lymphatic glands of the axilla or neck.

Prognosis.—Timely and radical operation ought to save at least 50 per cent. of the cases, and the mortality from the operation *per se* should not exceed 1 per cent. The test of cure is the passage of three years after the operation without recurrence (Volkmann). Pregnancy hastens the fatal result.

PAGET'S DISEASE, OR EPITHELIOMA OF THE NIPPLE.—This is a form of slowly progressing epithelioma resembling eczema, and begins on the surface of the nipple or areola as a chronic inflammation with desquamation of the epithelium, or a red and ulcerated surface with a slight discharge of bloody serum. The disease may continue in this form for several years, the epithelial cells gradually penetrating the basement membrane and infiltrating the deeper tissues

until nodules can be felt in the gland, or lymphatic or metastatic infection becomes evident. The *diagnosis* from *eczema* is made by its obstinate resistance to treatment, infection of the lymphatics, and by microscopic examination. The *treatment* is the same as that for other forms of cancer.

Sarcoma of the Breast. — All varieties of sarcoma are met with in the breast, but the most common is the spindle-celled.

Sarcoma usually occurs in patients from eighteen to forty-five years of age, beginning as a small painless tumor near the nipple, which grows rapidly, reaching the size of an orange or cocoanut in a few months, often with fluctuating points due to cystic changes. The veins in the skin covering the tumor are dilated, and while the skin is not involved in the disease it may give way to pressure, with ulceration and projection of the tumor as a bleeding fungous mass. The nipple is seldom retracted, but it may discharge bloody serum. The lymphatic glands of the axilla are infected in about 15 per cent. of the cases. If the disease is permitted to run its course, secondary tumors occur in the lungs, liver, and brain, and death frequently results in less than one year, sometimes as late as three years.

The *diagnosis* is made by the youth of the patient, the rapid growth of the tumor, the enlarged veins, the increase in the surface temperature of the breast, the absence of adhesions to the skin, and the infrequent infection of the axillary glands.

Endothelioma is a variety of sarcoma (Ziegler), originating from the endothelium of the blood- or lymph-vessels, hæmangio- or lymphangio-sarcoma. By some it is regarded as cancerous,—a transition tumor between sarcoma and carcinoma. It occurs in elderly persons, grows rapidly, causes general metastasis, with little tendency to infect the lymphatics except when occurring in the lymph-vessels, but has a tendency to adhere to the skin.

Treatment of Malignant Tumors of the Breast.—In 1875 Volkmann advised and practised complete removal of the breast, with the pectoralis major and minor muscles and the axillary glands, but he did not perform the operation as a *routine method*, as is done by most surgeons of the present day.

Operation.—Prepare the patient for the operation by shaving and disinfecting the chest, neck, axilla, and arm, and enclosing the patient's head and hair in a cap or towel. Separate the patient's face from the field of operation by a sterilized sheet, beneath which the anæsthetic is given, and extend the arm from the side at a little more than a right angle. Make an elliptical incision around the breast, including the tumor, well beyond the limits of the disease, and extending along the posterior border of the pectoralis major muscle

to the outer border of the axillary space. Divide the skin, superficial fascia, and fat, and dissect them from the muscles until the origin of the pectoralis major from the clavicle and costal cartilages is exposed. Divide the muscle at its origin and turn it up with the breast until the origin of the pectoralis minor is in turn exposed and divided. In many cases the clavicular origin of the pectoralis major may be left, the muscle being split out to its insertion, and the pectoralis minor may be left if the disease is not too far advanced. The entire mass of breast and muscles is reflected outward towards the axillary space, which is opened by carefully dissecting along its anterior border until the axillary vein is exposed. The insertions of the pectoralis major and minor are divided and the glands and fat in the axilla and along the side of the chest wall, up to a point beneath the clavicle, are removed. Dissect the glands and fat away from the axillary vein, artery, and the nerves of the axilla, from the surface of the serratus magnus, covering the side of the chest, and from the anterior surface of the latissimus dorsi and subscapularis. Do not injure the posterior or long thoracic and the subscapular nerves. Stop all bleeding and close the wound with sutures, and if necessary introduce "tension sutures" at intervals. If the hemorrhage has been thoroughly arrested, no drainage is necessary; otherwise make a puncture through the skin in the axilla and insert a rubber drainage-tube, which may be removed at the first dressing after the operation. If the edges of the wound cannot be brought together, Thiersch's method of skin-grafting should be used at once, or after granulation begins. The dressing is applied so as to make equable pressure and prevent the formation of dead spaces, which invite the accumulation of serum or blood. The arm should be included in the dressing and fixed to the side by means of a bandage. If all goes well, the dressings need not be disturbed for a week.

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